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ABSTRACT

This curriculum guide is designed as a basic outline of course content, teaching procedures, and emphases for life science in Grade 7. Guidelines for teaching units are prefaced by a list of basic themes of science. Each unit includes a short introduction for the teacher, suggestions for student activities, a list of emerging concepts, and lists of equipment needed, films, other aids, and references. Units are entitled "Use of the Senses in Learning from Nature," "Differences Among Living Things," "The Human Organism," "How Life Continues from Generation to Generation," and "Responsibilities to Other People." Included are a general reference list and lists of needed equipment and supplies. (EB)

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SCIENCE FOR GEORGIA SCHOOLS

JUNIOR HIGH LIFE SCIENCE
Volume III-A

Preliminary Edition

Division of Curriculum Development
Office of Instructional Services
Georgia Department of Education
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Jack P. Nix, State Superintendent of Schools
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PLEASE NOTE

This preliminary edition of Volume III-A of Science For Georgia Schools, Junior High Life Science, is being issued in very limited numbers. Much care has been taken in selecting the people who receive copies of it. It is expected that these people will offer a written critical review of this publication which will be used in determining the form of the guide to be used for general distribution.

A record has been kept of your having received this guide. It is hoped that you will voluntarily submit your review during the 1969-1970 academic year. This is not to imply that any coercion will be used to require you to make this criticism, but hopefully you will see our need to share your expertise.

The original writing team put forth considerable effort to make this science guide accurate, both scientifically and pedagogically. But the writing team will be the first to admit that many errors have occurred in both categories.

Please use your interest, ability and time to find these errors, report them to the Division of Curriculum Development, Georgia Department of Education, and help make this publication as effective and useful as possible.

SUGGESTED FORMAT FOR REPORTING CRITICISM

I. Errata (page and line numbers)

II. Scientific inaccuracies

III. Pedagogical errors

IV. Suggestions for additional sections or chapters

V. Other criticism

VI. Name and title of reviewer

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FOREWORD

Earlier volumes of this series, "Science For Georgia Schools," were concerned with curriculum guidance for the elementary grades. They attempted to put into an orderly sequence the multitude of activities appropriate for these years. In addition, they attempted to show the inseparable interrelationships between matter and energy as they affect the broad areas of living matter; rocks, soils, and minerals; earth and space; electricity and magnetism; heat; sound; light; properties of matter; and air and water. These earlier guides were characterized by consistent internal themes which led the elementary students to broadened insight in the realm of scientific knowledge and increased skill in the process of science.

As the years passed by, new kinds of needs developed for science in the intermediate or junior high school years. Possibly the most fundamental of these needs arose from the advent of the junior high school itself in Georgia. As school populations increased, the logical curriculum reorganization pattern for many Georgia communities was toward the junior high school arrangement. It was felt that if special intermediate schools developed, then special science curricula should be made available for them.

Curriculum developments in the senior high schools also changed the requirements for science in the junior high school years. National curriculum studies such as PSSC Physics, CEMS Chemistry and BSCS Biology, with their quantitative, laboratory centrality, called for students with different kinds of skills. Students who were successful, at least in part, because they understood how to function in open-ended laboratory experiences. The implication is then, that prerequisite coursework for these new curricula should be developed.

Our emerging society also demands special materials for the junior high school. As the population becomes more urban, students are farther removed from their natural environment and more closely associated with a complex technological environment. Concomitantly, mankind's need for efficient utilization of the earth's resources increases. So there arises in the schools the desirability for instruction in earth and environmental sciences. If citizens are to make wise choices concerning the use of this planet's natural wealth, then they all must understand the nature of the work of the earth scientist, his successes and his limitations.

Similarly, the combination of factors make special attention to the life sciences in the junior high school desirable. These factors include the nature of new biology curriculum materials for the senior high school, the fact that some students still do not attend senior high school, and the fact that increased population density has had attendant increases in certain diseases and health problems.

Traditional concepts of physiological structures and processes have been deemphasized in new biology curriculum materials for the senior high school. There should be some time during the public school years for all students to learn something about the construction and operation of the human organism, to learn basic ideas of human reproduction and genetics and to learn fundamental ideas about the mechanism of disease vectors which affect human welfare. The junior high school is an appropriate time for this effort.

The real world of today's citizen is the technological world, and the basis for this technology is the physical sciences. Therefore, all citizens should know the basic principles and laws which govern technological phenomena. Besides knowing these principles and laws, today's citizens should have appropriate skills enabling them to bring these principles and laws to bear on problems which they encounter in day-to-day existence. This, then, is part of the rationale for emphasizing in the junior high school years coursework in introductory physical science. A second, but more limited, reason for teaching the physical sciences is the new curriculum materials in science for the senior high school. Effective instruction in the Biological Sciences Curriculum Study laboratory materials demands that students have background in fundamental laws of physical science. The laboratory experience in physical science in the junior high school permits the development of familiarization with laboratory procedure characteristic of the high school years.

Three volumes of this curriculum guide for science in the junior high school are being written then, to provide learning experiences in life science (Volume III-A), earth science (Volume III-B), and physical science (Volume III-C). Publication of subsequent Volumes III-B and III-C will be made available to schools as quickly as the mechanics of editing and printing can be accomplished.

The writers have prepared these materials so that they can be used in sequence, with life science being presented in the first of the junior-high years, earth science in the second and physical science in the third. The writers recognize that this sequence may not be the most desirable one for every school using these materials. It will be possible, therefore, to divide each course so that a portion of each may be presented during each year of the junior high school sequence. The essential consideration is that all these materials be presented during the junior high years.

During the summer of 1967, a writing team under the direction of Dr. Johnathan Westfall of the University of Georgia assembled to write this guide. The team was composed of Louis Hornsby, Albany High School; Mrs. Gladys Atkinson, Dykes High School, Atlanta; Mrs. Nannelle Bacon and Mrs. Bobbie Gamble, Bacon County Junior High School; Mrs. Linda Chapman and Mrs. Rosemary Strother, Clarke County Junior High School; Mrs. Dorothy Evans, DeKalb Junior College; Barney Purvis, Irwin County High School and Henry Weissinger, Muscogee County Schools.

Gratitude must be expressed in advance for those who will offer critical review of this preliminary version of Volume III-A, Science For Georgia Schools. The work done by the writing team cannot be judged without the thoughtful criticism of both professional scientists and science teachers. Only after this first effort is modified by the expertise of scientists and the experience of teachers will it be possible to publish this guide in a final form for general distribution to all people in Georgia concerned with the development of the science curriculum in the junior high school grades.

INTRODUCTORY MATERIAL

OBJECTIVES

The broad general objectives for this science curriculum guide, as stated below, are not to be considered restrictive for this guide's users. Each school, or even each teacher, may have need for additional objectives particularly desirable for the students in the classes immediately involved. Having the following objectives in mind, however, will enable the user to "think along" with the curriculum writers, so that he may better understand reasons for the choices of the particular set of student learning experiences suggested in the development of the guide.

1. A capstone for the elementary science program will be provided and a general background in science will be provided to the many students who leave school after completing junior high school. As future parents and citizens, these students need a practical introduction to biology, the earth sciences, and the physical sciences that will serve as the basis on which they will make future decisions of importance to themselves, their families, their communities and the nation.

2. The appropriate science background for students who plan to take courses in biology, chemistry, or physics in senior high school will be provided. A year each of life science, earth and space science, and physical science in junior high school will enable students entering science classes in senior high school to start at a more advanced level and to progress faster and farther than would be possible otherwise.

3. The student will be helped in developing an understanding of the nature of science, its methods, its spirit, and its limitations.

    a. Science is a process that utilizes a variety of methods to develop reliable knowledge.

    b. Science requires curiosity, observation, experimentation, skills, record keeping, description, thought, evaluation, and explanation.

    c. Science is a social endeavor; it changes society, and it depends on society for freedom to investigate and to communicate.

    d. Science is dynamic. As new information is added to the accumulated knowledge of the past, ideas and concepts change.

    e. Science should be included as part of the general education of all citizens. If our civilization is to continue to be enriched and strengthened by the contributions of science, a knowledge of the aims, methods, and benefits of science must be extended beyond the possession of scientists, and must be shared as part of the common knowledge of all members of the community.

4. Junior high school science will emphasize and illustrate, both in procedure and content, the following attributes of science:

    a. Science operates on the assumption that the regularities of the universe are dependable and not capricious.

    b. By studying small samples of the universe one at a time science proceeds toward an understanding of the more comprehensive and unified aspects of nature.

    c. Science is not a finished enterprise; many principles and interrelationships governing the behavior of things in the universe are still undiscovered.

d. Measurement is essential to science because the formulation and confirmation of laws are dependent on exact quantitative and qualitative distinctions.

e. The general ideas and theories of science are of a tentative nature; our view of the world changes with the accumulation of knowledge.

f. The laboratory, the place where the scientist works, is at the heart of the scientific enterprise. It is here that the scientist asks questions of nature and attempts to discover the answers by accurate observation, precise measurements, and controlled conditions.

5. More specifically, a junior high school science program should achieve the following objectives:

   a. Skills in making and recording measurements accurately should be developed.

   b. The tentative and changing nature of scientific theories should be understood.

   c. Proficiency in working independently in gathering information, observing accurately, using apparatus, drawing logical conclusions, and reporting findings clearly should be acquired.

   d. Using library and classroom references to supplement classroom and laboratory activities should become habitual.

   e. Students should develop awareness of the ever-changing nature of science as illustrated by current developments as reported in newspapers, news magazines, periodicals, and other news media.

USING THE GUIDE

This guide, when completed in all three forms, will include outlines, suggestions and references for a coordinated series of units in science for grades seven, eight and nine. The series begins with simpler and more familiar ideas and progresses toward more complex and more highly sophisticated concepts. Although as a matter of strategy emphasis is centered on a different broad area of science in each of the grades, the three volumes of this material will direct attention to numerous opportunities for stressing the basic unity of science by interrelating concepts and ideas developed at each of the three levels.

Logical Organization for Learning

The content of this curriculum guide has been planned and organized in keeping with stated objectives and rationale. To achieve these objectives those selected areas of science in which the pupils will gain knowledge and understanding have been divided into interrelated units. These units have been further broken down into subtopics. This systematic organization of instructional materials is based upon a logical and orderly sequence in which previously introduced ideas and concepts are related to those that follow. The organization of materials thus reflects the orderly and systematized nature of science itself. Moreover, the curriculum guide has been planned to develop skills of increasing complexity to be applied to the reorganization, synthesis and application of knowledge and ideas.

Whether or not the coherent structure and continuity thus provided will be obvious and of aid to the student will depend largely upon the interest and skill of the teacher. The structured nature of the curriculum guide is based upon the premise that learning takes place best in a context that relates to previous knowledge and concepts and that serves as a foundation for future learning. A logical sequence in the curriculum helps to establish readiness for more advanced learning, and it makes each new step more logical and reasonable.

The Format of the Curriculum Guide

A teaching procedure consistent with the stated objectives of instruction emphasizes science as a structured body of knowledge, as processes of inquiry, and as strategies of investigation. These emphases are reflected in the format of topics in the curriculum guide.

Typically, each topic is introduced with a short introductory statement which generally consists of information or advice for the teacher. This leads to the topical outline and suggested activities which are followed by reference lists of appropriate state-adopted textbooks and other suitable reference materials. Additional lists of needed equipment and materials, suggested films and other visual aids are also provided.

The curriculum guide is designed as a suggested basic outline of course content, procedures and emphases for science in grade seven. It has not been designed to be used rigidly and without imagination. It should serve as a skeletal guide upon which the teacher builds a more complete and detailed guide of her own, with modifications and adaptations suited to her particular student or group needs.

Finally, there is a list of emerging concepts. Obviously, the teacher needs to have these in mind from the beginning of her planning. Although they are of foremost importance, they are placed last because they really represent solutions to problems or unifying concepts arrived at by the student through the process of relating facts, theories, observations and experiments. The over-anxious teacher needs to exercise restraint sufficient to allow the student to work out his own synthesis or solution. To be sure, proper guidance is appropriate and sometimes essential, but zeal to inform should not be allowed to deprive the student of the joy and satisfaction of arriving at his own new insights and discoveries -- new at least for him.

Emphasis on Methods and Procedures

The value of the curriculum guide depends largely upon how the suggested instructional materials are taught. The style of teaching is of paramount importance. It is influenced strongly by the goals of instruction and by the intrinsic nature of science itself. Science taught authoritatively and dogmatically as a series of unqualified, positive statements has the advantage of simplicity, but it leads to a false and misleading picture of science. It gives the pupil the impression that science is made up of fixed, final and unalterable truths. It further leads to the false impression that science is complete, that there is nothing left to be discovered. It fails to portray science as it really is -- a body of knowledge gained slowly and tentatively from data derived through carefully planned observations and experiments. The methods of science are among its most important discoveries.

The value of the curriculum guide will depend largely on the extent to which it is used to teach science as inquiry and to show how areas of inquiry may be summarized and unified by major conceptual schemes or "big ideas." This means simply that its value will depend on the extent to which some of the conclusions of science are presented in the context and framework in which they arise and are tested.

Instruction is a dynamic link between the curriculum and teaching goals. It is the function of the interaction of pupil and teacher. Learning implies doing something -- action. The laboratory is the place for labor.

In order to permit a proper latitude of flexibility and choice, more suggested activities have been listed than will usually be needed. This surplus of activities permits the teacher to choose and adapt materials to the needs and achievement levels of different individuals or groups. Use of the curriculum should not prevent the teacher from being alert constantly to additional and related problems that may arise more or less spontaneously in the classroom or laboratory. Worthy suggested activities from students may sometimes be substituted for related activities in the curriculum guide. Such student suggestions may have the merit of immediate and obvious significance to the students themselves.

Previous Planning

Emphasis on the process of inquiry and the laboratory approach makes thorough planning mandatory. The time for previous planning for a particular unit occurs in two periods. First, several months in advance, needs for the entire course must be checked and orders placed for supplies, equipment, films, slides, filmstrips and references. Second, the materials for particular unit or major topic must be assembled a few days in advance and kept in specifically designated boxes or shelves ready for use.

Since the study of living things requires that they be available in the classroom, a schedule of planning is necessary. For example, experiments requiring seed germination may require planting five days to two weeks before seedlings are to be used. One to two weeks may be required for the growth of a culture of protozoa. A master chart of preparations should be worked out and posted for use by student assistants. Students may be required to plant seeds which will not be used further for one or two weeks.

Equipment and supplies needed for each unit are listed after the suggested activities for that unit. Catalog numbers of films available from the Georgia Film Library are indicated with most film resources. Recommended films unavailable from this source have addresses appended which will enable users to get further information about these visual materials.

Abbreviated bibliographic references are made with each unit. Complete publication reference data can be found in an extensive bibliography beginning on page 103 of this volume.

PERMEATING BASIC THEMES OF SCIENCE

At any level of science teaching the teacher needs to be aware of the cognitive skills expected of the student at that level of achievement. A wise choice of instructional materials is clearly related to the needs and problems of students. This choice is logically based upon the identification of the most comprehensive and unifying concepts that are known to modern science. The choice is further governed by the appropriateness of the material for a given level and the degree of sophistication to which concepts and ideas can be developed. In the past much of this choice has been based upon tradition or upon trial and error. Within recent years there has been mounting concern relating to the identification of the most residual, permeating, and integrating ideas which reflect the true nature of science and which contribute most to the students' personal lives and to their future roles as citizens.

Knowledge as such may be fragmentary, unorganized, and unrelated to unifying ideas and concepts. Effective science teaching requires a recognition of the major concepts or permeating threads of thought which organize scientific facts and give them broader meaning.

The Permeating Basic Themes of Science listed below are largely modifications of "Conceptual Schemes" prepared by a committee organized by the National Science Teachers Association in 1963 and later published in their booklet, Theory into Action 1964, and upon "Unifying Themes of Biology" identified by the Biological Sciences Curriculum Study.

1. All matter is made up of units called fundamental particles. Under certain conditions these particles can be transformed into energy, and vice-versa.

2. Units of matter interact. All ordinary interactions involve electromagnetic, gravitational or nuclear forces.

3. All matter exists in both time and space, and since interactions take place among its units, matter changes with time. Such changes may occur at different rates and in various patterns.

4. All interacting units of matter tend toward equilibrium states in which there is minimum energy and uniform, simple disorder. Complexity involves the idea of improbability; the more complex an organism or system is, the less the probability it arose by chance. Unless energy is expended for work, organization tends to assume the most probable state -- disorder. The complex, improbable living organism needs energy for work and it requires information or instructions for using the energy. In the processes leading toward equilibrium, energy transformations, matter transformations, and energy-matter transformations occur, but the sum of energy and matter remains constant.

5. One of the forms of energy is the motion of the units of matter. Such motion is responsible for heat and temperature and for the solid, liquid and gaseous states of matter.

6. Matter exists in a variety of units which differ in complexity of organization, from the simplest fundamental particle to the galactic universe; it varies from non-living to living; and among living matter from cell to organism, community and world biome. As one progresses through the various organizational levels

from the simplest to the most complex, the units of organization become more diversified, more intricate, more involved and more difficult to describe in simple, general laws.

7. The behavior of matter in the universe can be described on a statistical basis. However, it is difficult, if not impossible, to reduce all biological principles to strictly physical bases, because properties of living things are not predictable on the basis of their chemical composition.

8. Evolutionary change through time has resulted in the production of a great diversity in living forms, and the diversity is based upon a relatively small number of unifying basic patterns.

9. Life is characterized by a continuous process of cell division that extends backward to the remote and unknown periods of the past. Individual bodies die, but germ cells live on, carrying with them the coded instructions that determine structure and behavior.

10. Living things at all levels of organizational complexity are changed by the environment and the environment is changed by them. The interactions of organisms with each other and with the nonliving environment creates the need for conservation practices, and knowledge of the interactions provides guidelines for effective conservation practices.

11. The vast range of behavior characteristic of organisms varies in flexibility and rigidity within limits imposed by their biological nature. Whether in an interplanetary spacecraft or at work in the laboratory, a person's behavior is limited and conditioned by his heredity and environmental past history. Learned behavior, based upon the experience of the individual and his forebears, as well as innate behavior, must operate within limits rigidly imposed by the biology of the individual.

12. Organisms tend to maintain a stable internal environment in the face of change. Internal stability consists of a complex of dynamic equilibriums (homeostasis) which are still sufficiently flexible to permit limited and long-term changes (regulation).

13. Science itself has several aspects. It carries the idea of process, of inquiry. Science also is a body of knowledge based upon data gained tentatively from observations and experiments which, in turn, arise from problems born of concepts. Because scientists are capable of error, their conclusions may be false or only partly true. The body of scientific information is not made up of unalterable, fixed truths; it consists of reports of things observed or measured and interpretations made from the data thus gained. Once conclusions are drawn, they are still subject to continuous re-examination and re-evaluation.

The Life Sciences In Grade Seven

The Life Sciences In Grade Seven

Introduction

Life science is not the same science it was 25 years ago. New instruments, techniques and perspectives, combined with a rapidly accelerating pace of research, have imparted to life science a dynamic, growing character marked by a rate of discovery that is increasing at an exponential rate. The increased rate of discovery has resulted in more than mere addition to the same kind of knowledge. Life science has moved in new directions. Under the impact of new discoveries and changing viewpoints, it has advanced from a largely descriptive body of knowledge to become a dynamic, experimental science that is progressively more dependent on mathematics, chemistry and other physical sciences.

Students coming to grade seven vary enormously in knowledge of chemistry, but most can be depended upon to have little more than the most elementary and fragmentary information.

Choice of topics to be emphasized in the life sciences for grade seven has been based upon the importance of the concepts included and upon the suitability of the material for this level of student development. The appropriateness of a particular topic depends not only on its intrinsic value to the education of all citizens but also on the level of sophistication to which it is developed.

As far as is possible, concepts requiring some depth in chemistry should be touched upon lightly or postponed for more complete study in tenth grade biology.

We think of science as having a dual role. Science is clearly distinguished by certain processes of inquiry and exploration, and it is also the resulting body of information. The processes of science typically have been the subject of confusion and misconception. Too often it has been taken for granted that there is only one scientific method and that it always begins with a problem and proceeds in logical steps to a conclusion or hypothesis. But problems do not arise full-blown. As products of thought, they are born within a conceptual framework of ideas, attitudes and abilities. Triggers that set off the thought process may vary. More often than not the scientist sees an event happen to something. On another occasion he may not actually see an event, but he may use scientific instruments to measure the nature and magnitude of an event not easily observed. On still other occasions the scientist may conclude from existing evidence that certain events occurred in the past. Whether or not objects and events are translated into relevant problems depends on the context of interrelated ideas within which they are viewed. For this reason it is difficult for a pupil in grade seven to assume the role of a scientist, but he is capable of a better understanding of the processes of science, their contributions, their potentialities, and their limitations.

Many people, of course, had seen falling objects before Isaac Newton, in the mid-seventeenth century, extended his terrestrial observations (the fall-of-the-apple story) to cover the entire universe. But they formulated no universal laws of gravitation because they lacked the necessary concepts to motivate and direct their thinking.

More than a century later, in 1774, Joseph Priestly observed that when mice were kept in a closed bottle for some time, the air became changed and the mice died. When new mice were placed in the bottle, they also died, but the "bad" air was soon regenerated and made usable by mice after green plants were placed in the bottles.

Even after these notable observations, Priestly failed to formulate even an empirical equation for respiration, because at that time oxygen and carbon dioxide were totally unknown. It is impossible to conceptualize in an information vacuum. Information concerning objects, processes and relationships, whether gained first-hand by observation and experimentation or vicariously by reading and discussion, composes the threads from which concepts are woven.

Previous to 1912, many geographers had, no doubt, noticed the congruity of the South American east coast and the African west coast, but not until that year did Alfred Wegener formulate his theory of continental drift based on data which convinced him that South America and Africa were once united as a single continent. In the mass of data which he accumulated and examined he was able to see relationships never fully comprehended before, and he realized their implications.

Cultural evolution includes the development of concepts that have been selected empirically for their contributions to survival. Among these there may be some which are based upon hearsay and superstition and which have outlived their usefulness. The advancement of science has depended upon a rigid separation and retention of the concepts that may be tested and verified and a rejection of testable concepts which do not conform to a true picture of the world. The orderly, testable explanations of the natural world are the conceptual schemes of science.

An understanding of the procedures and contributions of science carries clear implications for methods and emphasis in science teaching. Students should be presented every opportunity to explore the natural world, using the methods which scientists have found to be dependable means of gaining reliable information. Moreover, students should be encouraged through actual practice to seek orderly explanations, to see interrelationships, and to use information to develop a body of concepts or unifying ideas.

Recent major science curriculum studies at the high school level have been developed around basic conceptual themes that have given organization and relevance to teaching materials and meaning to procedures. Emphasis on these basic concepts has influenced the selection of materials and has governed the choice of methods. These changes have led to a reevaluation of science teaching in junior high schools and in the elementary grades.

Progressively, as a national trend, increased time has been allotted to science in the elementary school and in junior high school. New emphasis on the processes of science has required more space for teaching and better laboratory facilities. Equipment needed to strengthen the science curriculum has been purchased, in many school systems, by use of funds provided through provisions of the National Defense Act of 1958.

Using The Curriculum Guide In Grade Seven

This guide for Life Science is intended to give unity, ordered sequence and direction to the year's study. It has been designed as a broad basis for the construction of lesson plans, and it provides sufficient latitude for the teacher to adapt suggested materials to various ability levels.

Emphasis is placed on laboratory work designed to provide opportunities to observe and to discover relationships. The pupil is provided opportunities to see things and to observe what happens to them under certain conditions. At first the objects and events observed may fail to suggest interrelationships or to raise questions. The pupil needs to learn from laboratory experience that objects and events tend to conform to predictable and regular patterns which often can be described or formulated as mathematical statements. But learning is a long and arduous journey.

The pupil cannot operate effectively within a knowledge vacuum. He must proceed from the more obvious and simple to the more complex and sophisticated. He must learn to realize from experience that unifying conceptual schemes are constructed painstakingly within a framework of interrelated ideas and knowledge.

Emphasis on a spirit of inquiry does not imply that the student is expected to discover everything for himself. He can learn to value what others have discovered, and, more importantly, he can learn to understand and appreciate the methods, attitudes, and skills that have been essential to the development of science. Before he can launch into meaningful inquiry or formulate relevant questions, he must learn how to observe things and events, to discover relationships and to suspect others relationships. In other words, he must learn through experience to operate within a conceptual frame-work which allows him to formulate problems and to propose appropriate methods for their solution.

The laboratory experiments and exercises suggested in the guide are designed to help develop the basic information from which some of the important ideas and concepts of life science have been constructed. Accordingly, much of the total class time should be devoted to such activities. Enrichment and elaboration appropriately follow, with additional reading in texts, periodicals, suggested references, films and other resources.

Before attempting to use the guide, the teacher should read through it completely in order to become acquainted with its overall design, the process-concept approach, and the subject matter content. A general schedule of time allowance is suggested in the guide. This needs to be further adapted to the school calendar and the needs of each teacher. Each unit needs to be considered and planned in advance of its use so that all materials will be available when needed.

Lists of advanced textbooks and sourcebooks for the teacher are provided on the following pages. A list of state-adopted textbooks for seventh grade science is also provided. Suggested audiovisual aids are listed with each unit.

Films and filmstrips need to be ordered well in advance of their scheduled time for showing. This is particularly true of films obtainable from commercial suppliers (often on free loan). As a rule, all films and filmstrips should be scheduled and reserved several months in advance. Additional books which you may wish to obtain for classroom and library reserve shelves are listed with the related units.

The following publications are suggested:

Advanced Texts:

Simpson and Beck, Life, Harcourt, Brace and World, Inc., New York, 1965.

Weisz, Paul, Elements of Biology, McGraw Hill, New York, 1961.

Keeton and Norton, Biological Science, W. W. Norton, New York, 1967.

Sourcebooks:

Morholt, Brandwein, Joseph, A Sourcebook for the Biological Sciences, second edition, Harcourt, Brace, and World, Inc., New York, 1966.

Miller and Blaydes, Sourcebook of Biological Science, second edition, McGraw Hill, New York, 1962.

National Science Teachers Association, How To Do It
Pamphlet series, Washington, D. C.

Wailes, James R., NSTA and NASA, Living Things,
Teachers Publishing Corporation, Darien, Connecticut.

The state-adopted texts for seventh grade science have influenced the organization of this guide and these should be available for student and teacher reference. The texts stressing life science will prove most useful in implementing the guide. It is hoped that every teacher will utilize the text available to her students as one of the many tools for enrichment. The list of state-adopted texts include the following:

Navarra, Zafforoni, Garone, Life and the Molecule,
Harper and Row, New York, 1966.

Mason and Peters, Life Science, A Modern Course,
D. D. Van Nostrand, Inc., Princeton, New Jersey, 1965.

Fitzpatrick and Hole, Modern Life Science, Holt, Rinehart
and Winston, Inc., New York, 1966.

Fitzpatrick, Bain, Teter, Living Things, Holt, Rinehart and
Winston, Inc., New York, 1966.

Navarra, Zafforoni, Garone, Today's Basic Science:
The Molecule and Biosphere, Harper and Row, Inc., 1965.

Choosing And Developing A Teaching And Learning Unit

Emphasis on Active Firsthand Experience

The verb to learn indicates action. It implies activity on the part of the learner. The cream of scientific information cannot be poured into pupils as water is poured into a container. Pupils must be involved actively in the learning process. That is, they must do things if the learning is to be vivid and well-remembered. A good science course involves pupils in a great variety of activities -- observing, asking questions, thinking, seeking answers, engaging in field trips, doing experiments, developing projects, reading resource materials, viewing films and slides, and assisting with chores in the laboratory.

The methods of learning a pupil cultivates may be at least as important as what he learns, because certain intrinsic methods of science are themselves among the greatest of scientific discoveries. Opportunities to gain information in the laboratory by firsthand experience are of necessity limited in number and variety. Books, films, slides, television and pictures are sources of a wealth of other people's experience, but at best they are supplementary and cannot take the place of firsthand experience.

Guiding Considerations in Choosing Units

For the purposes of strategy and convenience a year's work is usually divided into broad areas of subject matter called units. It is usually desirable to arrange these units so that earlier units provide information and ideas needed to develop those which come later. Such a sequence has the added advantage of presenting science as an organized and systematized body of information, ideas and concepts rather than as a hodge-podge of unrelated facts.

There is more than enough diversity of material within each of the broad areas of science to sustain attention and to appeal to pupils of different interests. Considerations which served as bases for the selection and development of units for Life Science in the Seventh Grade are:

1. Each unit should be an integral part of a sequence in which earlier units provide the information and concepts needed to develop later units.
2. Interest-killing repetition should be avoided, but units should be interrelated as much as possible.
3. As much as possible, each unit should be built around many firsthand, individualized laboratory experiences.
4. The range of materials should be sufficiently wide in both scope and difficulty to appeal to all pupils.
5. Provisions should be made for the more capable pupils to extend their activities beyond the limits expected of less capable classmates.
6. Each unit should have application and relevance to the lives of the pupils.
7. As much as possible, the units selected should reflect accurately the present position of science and the nature of science, not science as it was thirty years ago.
8. Units selected should appeal to the interests, needs and comprehension of pupils at the seventh grade level.

Suggested Time Schedule

The following time allowances are suggested. Experience may indicate, however, that individual teachers will find it advisable to modify the schedule to fit the needs of particular situations.

Unit I	approximately 2 weeks
Unit II	approximately 10 weeks
Unit III	approximately 10 weeks
Unit IV	approximately 8 weeks
Unit V	approximately 4 weeks

UNIT I. USE OF THE SENSES IN LEARNING FROM NATURE

Introducing the Unit

Man learns through his senses. This fact seems so obvious that science students may fail to appreciate the need for its emphasis. Regardless of the complexity of an experiment or the number and sophistication of its methods, we are still dependent on our senses. They are admittedly limited in the kinds and quantity of information they can give us. Various types of instruments, such as microscopes, spectrophotometers, computers and an imposing array of electronic measuring devices are used profitably to extend and sharpen the senses, but they cannot substitute for them.

There is no single scientific method. The several methods of science employ the senses in observation, experimentation, comparison of experimental and control groups, exact measurement, record keeping, organization, analysis, discussion, evaluation and reporting. At a simplified level pupils may be introduced to several of these methods in the following suggested activities.

Since the sense of sight, as well as other senses, will be used in these activities, the materials needed should be collected and stored in a convenient place before the beginning of class. If several sections of the class are to be taught during the day, it may be desirable to make several changes in the articles used in each activity from section to section.

Pupils will need data books to keep records of observations and experiments. Although one pupil is suggested for each activity, several may be included to illustrate the effects of individual differences and the nature of experimental error. Because of the nature of these exercises, there are advantages in conducting them as teacher demonstrations, with students in the roles of observers, listeners, feelers, tasters, etc.

USES OF THE SENSES IN INVESTIGATION

Introductory Material

During the performance of the demonstrations, such as the activities suggested below, there is usually a tendency for the teacher to provide too many questions and answers. This may be necessary in the initial exercises, but as the pupils learn to take over the experiments themselves in the later exercises, they should be encouraged to provide their own questions and answers. During each experiment, the teacher and the pupils not directly involved will need to have agreed beforehand to withhold information and suggestions that would tend to invalidate the experiment.

Suggested Activities

1. Have a pupil who has first been blindfolded touch a soft toy, a plastic cup, a paper cup, sandpaper or a similar object. After the object has been put away, have the pupil write a description of each object examined by touch. At the end of the activities, have him read his description to the class. Items may be listed on the blackboard at this time and checked for accuracy of description.

2. Have a second pupil, also blindfolded, listen to cloth being torn, paper being crumpled, and metal being tapped. Have him write his best description of each.

3. Have another blindfolded pupil smell colorless liquids, such as water, ammonia (caution!), onion-water and alcohol. Let him write his best identification of each.

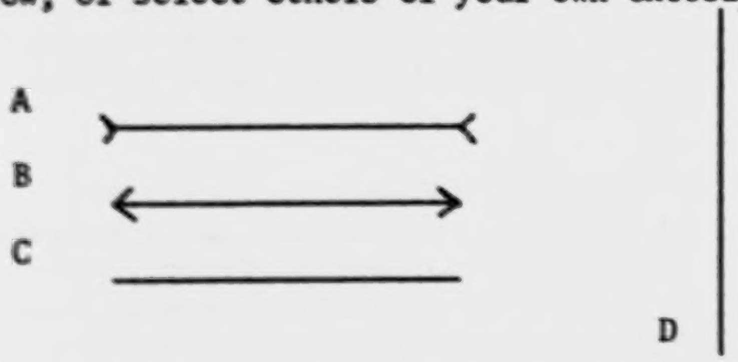
4. Have another pupil observe a clear bottle of orangeade colored with green food coloring. Let him write his best description of the substance.

5. Before pupils taste the following substances, warn them not to swallow while tasting. Provide water for rinsing the mouth after tasting each substance. Warn that it is dangerous to taste unknown substances, and that even in this case precautions need to be taken.

   Have a blindfolded pupil taste salt, vinegar, powdered saccharin and the liquid used in 4 above. Have him identify each.

6. How reliable or unreliable is feeling as a way of telling temperature accurately? See reference 1, p. 23.

7. Prepare charts or transparencies in advance showing optical illusions as given below, or select others of your own choosing.



   After having chosen what appears to be the longest and shortest lines, have some of the pupils measure them accurately. Have them write their conclusions as to the accuracy of observation unaided by measuring devices.

EXTENDING AND REFINING THE SENSES BY USE OF INSTRUMENTS

Suggested Activities

1. Have members of the class suggest means by which the temperatures of the three pans of water (section 6 above) may be determined.

   Prepare similar pans of water and record the temperature in each pan. Use both Fahrenheit and Centigrade thermometers. See reference 2, pp. 360-362.

2. Have the pupils estimate the weight of an inflated football in grams. Then have them weigh it on a platform balance and record the estimated weight and the determined weight. Deflate the football and weigh it again. Account for any differences in weight.

3. Provide each of several pupils containers of different sizes and ask each to draw from the faucet what they would estimate to be a standard cup of water. Then measure each sample by the use of a standard one-cup measure. Record the results.

4. Provide several pupils with pieces of string more than a meter long. Ask each pupil to estimate the length of string that measures a yard or meter and mark that length on the string. Have each pupil measure the marked length of string with a yardstick or a meter ruler. Record the results.

5. Ask pupils to examine their hands, giving particular attention to the skin. Have them write a brief description of the skin. Allow them to examine the skin of their hands under the stereomicroscope, and them rewrite their descriptions. Discuss reasons for changes in the second descriptions.

6. Have pupils look out a window and observe some distant objects which cannot be identified. Have the same pupils observe the objects through field glasses (or a telescope). See if they can identify the objects. Record the results.

7. Ask pupils to describe the arrangement and numbers of bones in their hands. Show them an X-ray transparency of bones in the hand and have them rewrite their descriptions.

THE NATURE OF EXPERIMENTAL ERROR

Introductory Material

Pupils need to learn early in the course that experimental work carelessly done is practically worthless. Moreover, no matter how well designed an experiment may be, there will still be sources of error that cannot be completely eliminated. Reasons for error frequently lie in faulty equipment, imperfect observations and inadequate techniques. Failure to observe carefully and to report accurately are common sources of error, especially among beginners.

Although errors can never be eliminated completely, well planned precautionary measures serve to reduce them to a minimum. Thus, the pupil in the role of investigator, should be called upon to be alert to possible sources of error. As he gains experience, he should be called upon to evaluate, to redesign and to repeat an investigation, if that seems to be necessary or advisable.

Suggested Activities

1. Using a balance scale and weights and a set of numbered wooden blocks, have several pupils weigh the same blocks at separate times, recording the weights. The first set of recorded weights should be handed in before the second weighing. After weighing has been completed, write all lists of recorded weights on the blackboard. Account for the differences in recorded weights for the same blocks. Discuss the sources of disagreement or error.

2. In a similar manner have several pupils determine the dimensions of the numbered wooden blocks, using rulers graduated in either centimeters or inches and fractions thereof. Record to the nearest marked fraction the length, width and height of each block. Compare different readings and account for the lack of agreement. How can experimental error be reduced in these two cases?

Emerging Concepts

1. We learn through the use of our senses.

2. The commonly recognized senses are: touch, hearing, sight, smell, and taste.

3. Information obtained through the use of one sense only is often inaccurate. Information based on as many senses as possible is likely to be more reliable.

4. Our senses cause us to make incorrect judgments in dealing with temperature, length and other aspects of our environment.

5. Observation can be made more accurate and exact by using certain instruments to extend and aid the senses.

6. Systems of measurement and measuring devices help us to express our observations quantitatively and thus more exactly.

7. To be scientific, information must be tested or verified.

8. Scientific inquiry is limited in the exactness and accuracy of its findings as inevitable sources of error. A well designed experiment attempts to reduce experimental error as much as possible.

Equipment

Fahrenheit and Centigrade thermometers, football, unit weights (grams), stereomicroscopes, platform balance, standard cup, string, ruler, microscope (low and high powers), hand lens, bioscope, field glasses, X-ray transparencies showing bones of the hand, data book.

Other Aids

Charts or transparencies to illustrate optical illusions (Use of Senses-7)

X-ray transparencies of the bones of the hand (Extending and Refining the Senses-7)

Films

1. You and Your Five Senses, e-j-s, 11 min., 976

References

1. Barnard, J., et al, Science: A Search for Evidence.

2. Wolfe, B., et al, Earth and Space Science.

3. Reidman, The World Through Your Senses.

UNIT II. DIFFERENCES AMONG LIVING THINGS: THEIR NATURE AND IMPORTANCE

DIVERSITY AND UNITY IN NATURE

Introductory Material

Through the range of manifold differences that exist among living things and nonliving things, there are a few basic patterns of likeness or similarity (unity in diversity). The fact that all matter, living and nonliving, possesses many properties in common is a unifying concept that tends to simplify our understanding of the world. Recognition of basic patterns in diverse types helps to establish order and interrelationships in an otherwise chaotic assembly of different forms. In order to comprehend this idea, the pupil must learn to recognize differences between living and nonliving things and to appreciate their many interrelationships. In addition, the student needs to learn by direct observation that the astounding diversity among living things exists within a few basic and interrelated patterns.

Most of the common minerals of the earth and the bodies of living things are composed of a relatively small number of substances called elements. Among the thousands of kinds of living things that possess an astounding array of differences in form, size and color, there are a few recognizable patterns. The concept of variety of type within a unity of pattern is so fundamental to life science that it should serve as a unifying theme throughout the course. It is the basis of natural classification and has its origin in the phylogenetic development of present day organisms.

Suggested Activities

1. Field trip: Field trip on campus and/or assignments for students to observe in their own yards and to collect specimens for class use. Plan well in advance. Equipment such as plastic bags, jars, trowels, forceps and insect nets should be assembled with assignments of certain responsibilities for each student or group of students. Be sure to have someone collect pond water or bring in some yourself. Also bring in a soil sample. Plans should be made for the care of living organisms until they are studied and a place should be designated in the classroom for the display of all items collected. After the class study, suggestions follow for the maintenance or preservation of the specimens. They will be needed for later activities.

   It is most important that students record in a data book (see Unit I) anything they perceive (plants, animals, rocks, soil, wind, rain, air, sunshine, etc.). They should record the habitat or place in which they find the living things. This information will be referred to as an analysis of the trip is made.

2. Class study: Items can be displayed on demonstration desk, tables, shelves, or desk tops. Data books should be open. Students can be asked to separate items that are most different or group those most alike. A microscope should be set up to show organisms in the pond water and one to show bacteria in the soil or other source. (Concepts 1,2, and 3.)

   Ask students to recall or to refer to their data books for anything else they perceived. (Concept 4)

   Ask students to name or list the organisms they found. These organisms make up a community. (Concept 5)

Ask students to recall any association between any organisms and any environmental factors. They might mention plants growing in the soil or lichens on rocks or plants or animals in water. These would be examples of interrelationships between organisms and the environment. (Concept 6)

This should lead to the idea that ecosystems vary in size and kind but that ultimately no natural ones are completely separate. (Concept 7)

As a last analysis ask students to recall any association between two different organisms. They will probably recall insects on leaves, lichens, one animal eating another, galls, fungi on tree limbs, etc. (Concept 8)

Concept 9 serves as a summary of the exercise.

3. Establish a terrarium or several terraria. The mosses, ferns and other small plants can be maintained for later study. As the terrarium is established, many points relating to organisms and environment can be brought out. (Concept 8) See reference 1.

4. Establish an aquarium or several aquaria. This can be done on an experimental basis, with water put in one, animals and water in one and plants and animals as well as water in a third. (Concept 4). See reference 1.

5. Press leaves or plants not placed in terrarium or potted. The pressed leaves can be used in studying types of leaves, etc. See reference 1.

6. The pond water should be kept and at intervals sub-cultures should be made by placing some of the original water in some fresh pond water. Succession will occur and many of the types of protists may disappear. If a student is interested, he could examine the water periodically for evidence of succession. Make a hay infusion culture using some of the pond water. See reference 1.

7. Insects can be pinned and kept in cases for further use. Small animals can be kept in terraria or maintained in well-ventilated jars. If they die, they can be preserved in formalin or 70% alcohol. The teacher should use discretion in keeping the specimens, but many organisms will be needed in later studies. See reference 1.

Emerging Concepts

1. Living organisms of our world exist as many greatly different types. These different types possess certain basic patterns of likeness.

2. Living things differ from nonliving things in that living things actively respond to the environment, they grow, and they reproduce more of their own kind.

3. For convenience, living things may be divided into three groups: plants, protists, and animals.

4. Factors such as light, wind, air, temperature, rocks, soil, lakes and streams make up the nonliving environment. One kind of organism will grow and reproduce best under one specific set of conditions, while a second kind of organism will survive best under a quite different set of conditions.

5. All of the organisms of a given area make up a biotic community.

6. The living community of organisms and its nonliving environment function together in an exchange of energy and materials as an ecological system or ecosystem. Man is included in this system.

7. Ecosystems may vary in size and type. There may be no sharp boundaries between them. All ecosystems of the earth -- the soil, the air, and the water inhabited by living things -- make up the biosphere.

8. Many types of interrelationships among living things are recognized, such as the relationship between the eater and the eaten (predator-prey), competition between individuals of the same species and among different species, animals eating plants (producer-consumer relationships), smaller organisms living in or on larger organism (host-parasite relationships), two organisms or populations living together in a situation in which one benefits and the other is not affected appreciably (commensalism), and an association of two individuals or species in which both benefit (mutualism). Organisms can be grouped for convenience according to the roles they play in the ecosystem.

9. Diversity in the nonliving environment and diversity in the roles of different kinds of organisms tend to permit each species to avoid competition with other species. Each species, in a sense, assumes the role of specialist for a particular set of activities which are related to but different from those of other species.

10. Man plays an important role in the many complex interrelationships among living things sometimes called the web of life. Unless constant care is exercised, man is always in danger of so upsetting the balance of activities in the web of life that his environment will no longer continue to support man himself. On the other hand, by understanding the diverse aspects of the environment, man can learn to cooperate with nature to his own advantage.

Equipment

Plastic bags, jars, trowels, forceps, insect nets, pond water, data book, microscopes, soil sample, slides, cover slips, terrarium tank, formalin or 70% alcohol solution

Other Aids

Filmstrips (consult your local and regional library)

Films

1. Nature's Half Acre, p-e-j, 33 min., 7052

2. Living and Non-Living Things, e-j, 11 min. 372

Films (continued)

3. Animal Habitats, p-e-j, 11 min., 956
4. Aquarium Wonderland, p-e-j, 10 min., 1497
5. A Balanced Aquarium, p-e-j, 10 min., 859
6. Partnerships Among Plants and Animals, e-j, 10 min., 1827
7. Life on a Dead Tree, e-j, 11 min., 1011

Resources

1. Turtox Biological Supplies, General Biological Supply House, Inc., 1967-68, 8200 S. Hoyne Ave., Chicago, Ill., 60620 (Turtox Service Leaflets are free. Order Number One through Number 60. This series of leaflets is an excellent reference source and can be used throughout this course of study.)
2. Biological Materials, Carolina Biological Supply Co., Burlington, N. Carolina, 27216. (Write for a catalog and ask to be placed on the mailing list for "Carolina Tips")
3. Ward's Natural Science Establishment, Inc., Catalog for Biology and Earth Sciences (Write for free leaflets on culturing organisms in laboratory or caring for organisms in the laboratory.)

References

1. Morholt, E., et al, A Sourcebook for the Biological Sciences.
2. Buchsbaum, R and L. Milne, The Lower Animals: Living Invertebrates of the World.
3. Miller and Blaydes, Sourcebook of Biological Science.
4. Wailes, J., Living Things.
5. Life Science Library.
6. Frisch, K., Man and the Living World.
7. Barnett, L., et al, The World We Live In.
8. Buchsbaum, L., Basic Ecology.
9. Cooper, E., Science In Your Own Backyard.

References (continued)

10. Allen, D., Our Wildlife Legacy.

11. Fenton, C. and D. Pollac, Trees and Their World.

HOW LIVING THINGS ARE DIFFERENT FROM EACH OTHER

Introductory Material

The primary purpose of the following exercises is to acquaint pupils with the nature of diversity among living things. The exercises are not designed as tasks in memorizing or learning systems of classification. Certainly the pupils will learn some classification, but this is not the primary purpose. As indicated in the title, the primary purpose is to give pupils an opportunity to see and appreciate the nature of the astounding differences among living things. Pupils progress from a recognition of the nature of differences to the use of these differences in grouping organisms on the basis of differences and similarities. These are "doing" exercises, in which the pupils utilize specimens already collected in the activities of the first section of this unit. Additional materials will be needed. The local health department, physicians, and veterinarians may be able to provide specimens of several animal parasites. The hay infusion prepared earlier in this unit may be used as a source of rotifers and several species of protists. The pupils themselves should be called upon to collect and bring in additional specimens.

Caution: Avoid making this a memorization exercise. Do not prepare duplicated copies of phyla to be given to the pupils. This will defeat the purpose of the exercise. The following suggested activities call for a study of plants, animals and protists which are representative of the whole spectrum of living organisms. Instead of using such a comprehensive group, however, the teacher may choose to use only animals or plants or even a subdivision of one of these groups such as insects or trees. Use textbooks, references, materials and films to reinforce and supplement observations.

Suggested Activities

1. Representative specimens (preferably alive) of the major subgroups of animals, plants, and protists should be placed on desks or tables throughout the room. They should be arranged randomly but in such a way that pupils can move from specimen to specimen at a signal from the teacher.

   There should be enough specimens to have one for each pupil. Each specimen should be designated with a numbered label which carries the common name of the fungi and certain protists. At first the pupils will need help in observing. The teacher may move along the rows to desks and ask the students questions that help to emphasize important differences and similarities. Then have the pupils prepare a list on the blackboard of the more important characteristics listed. From this list each pupil should prepare a chart in his notebook in which the principal characteristics are listed. For example:

Specimen No. and name	No. Legs	Eyes	Jointed (segmented)	Not Jointed	Leaves	Roots	Stems	Flowers

   The characteristics listed will obviously depend upon the nature of specimens used. Such time-honored differences as vertebrate vs. invertebrate and vascular plant vs. non-vascular plant have little meaning here because these important characteristics cannot always be ascertained by examining the specimen externally.

   After each pupil has studied 10 or more specimens, ask the pupils to arrange the specimens in three or four groups on the basis of similarities and differences. This will require insistence on careful observation and a quiet, well-ordered exchange of ideas. After the initial grouping has been completed, have the pupils make a list of distinguishing characteristics which members of each group have in common. Use letters A, B, C etc., to designate each group. Then have the pupils divide each group into two subgroups on the basis of similarities and differences. Repeat the process until there are 12 to 16 subgroups. List on the blackboard the distinguishing characteristics of each group, using numbers or letters to indicate the different groups.

   Have the pupils arrange the groups in order from the simplest to the most complex. Some time will be needed to decide just what is meant by the terms simple and complex. Size alone, for example, is not a reliable index of complexity.

   Remind the class that up to this point attention has been focused on differences and similarities as the basis for grouping organisms, without naming the groups thus established. The next step consists of identifying the various groups with categories already described and named by biologists. Discuss each pupil-established group. Call for suggested names for each group. List these names tentatively. Assign readings in textbooks and references. After pupils have compared their groupings with those used by biologists, allow the pupils to rearrange the specimens into accepted groupings. Have the pupils analyze why their groupings did not always conform to those of biologists. Have the pupils then label each group as to kingdom, phylum, sub-phylum, class, order or family as may seem appropriate, depending on the species used. Discuss the necessity of classification. Distinguish between identification and classification.

Suggested Activities (continued)

2. Dividing two phyla into classes

   Display representative members of the Vertebrata on the demonstration table. After pupils have examined and observed these specimens carefully, have them list outstanding similarities such as (1) backbone, (2) endoskeleton, and (3) appendages in pairs. In addition to these points of similarity, have the pupils list conspicuous differences.

   The above type of exercise can be repeated using the phylum Arthropoda, Bryophyta, or Pteridophyta or any appropriate subdivision, depending on the availability of materials and the teacher's familiarity with these taxa.

3. Discovering the characteristics of other phyla or subdivisions thereof

   Observe carefully the members of each of the groups identified in part 1, and allow enough time for the pupils to discover the major similarities of each group. Films may be used to discover or to emphasize other characteristics. As each group is studied, have examples and characteristics recorded on the blackboard. For their own records, pupils should record the information in their data books.

Emerging Concepts

1. One of the most useful methods of grouping organisms is on the basis of similarities and differences.

2. Careful grouping according to similarities and differences in structure can be used to arrange organisms into groups already described and named by biologists.

3. On the basis of similarities and differences, larger, more inclusive groups may be subdivided into smaller groups, such as orders, families, genera, and species.

4. Living organisms may also be classified on the basis of functional and developmental characteristics.

5. In general, organisms that are structurally and functionally similar are thought to have common ancestry.

6. The three major subdivisions of living organisms recognized as kingdoms by most modern biologists are plants, animals and protists.

7. The subdivision of science that deals with the laws and principles of classification is called taxonomy.

Equipment

Specimens representing a wide range of types within the kingdoms, phyla, classes, or orders to be studied, compound microscopes, and stereomicroscopes

Other Aids

A set of filmstrips on classification; transparencies or slides on the groups to be studied

Films

1. The Joint-Legged Animals: Arthropods, j-s, 18 min., 5396
2. Worms: The Annelids, j-s, 18 min., 5271
3. Arthropods: Insects and Their Relatives, j-s, 11 min., 1787
4. Beach and Sea Animals, e-j-s, 11 min., 273
5. Animal Life at Low Tide, e-j, 11 min., 1368
6. Animals with Backbones, e-j, 11 min., 1872
7. Mollusks, e-j-s, 14 min., 4924
8. Classifying Plants and Animals, Coronet Films
9. Simple Plants: Algae and Fungi, j-s-c, 14 min., 4178
10. Thallophytes, Small Bryophytes and Pteridophytes, Bowmar

References

1. Buchsbaum, R., Animals Without Backbones.
2. Booth, How to Know the Mammals.
3. Care and Feeding of Laboratory Animals, Ralston Purina Co.
4. Collins, H., Complete Field Guide to Animal Life.
5. Farb, P., The Insects.
6. Delauney, Deotto, The World of Microbes.
7. Experiments with Protozoa, Curriculum Aid No. 1, Wards Natural Science Establishment, Inc., Rochester, N. Y., 14603. Free
8. Frasier, R. and H. Smith, The Biological Sciences.
9. Hegner, R., Parade of the Animal Kingdom.
10. Jacques, H., How to Know the Insects.
11. Reidman, S., Naming Living Things.
12. Navarra, J., et al, Today's Basic Science: The Molecules and the Biosphere.

References (continued)

13. Sanderson, I., How to Know the American Mammals.

14. Zim, H. and C. Cottam, Insects.

15. Zim, H. and D. Hoffmeister, Mammals.

16. Zim, H. and A. Martin, Trees.

UNITY IN DIVERSITY AMONG PLANTS: HOW PLANTS ARE SIMILAR AND DIFFERENT FROM EACH OTHER

Introductory Material

The main purpose of this study is to help pupils observe the basic similarities among plants and to appreciate the nature of their differences. A secondary purpose is to show how similarities and differences can be used to group plants in classification systems which reflect supposed relationships. Pupils should be made aware that the major and more inclusive groups include organisms possessing a wide range of diversity, while subgroups include organisms that are less diverse and much more alike.

Suggested Activities

1. Arranging and Organizing Plants Into Major Groups

   Have specimens representing the major plant groups distributed throughout the room for easy examination and study: algae (Pleurococcus from tree trunks or old weathered boards, other algae from aquaria, ponds or springs), fungi, mosses, liverworts, ferns, clubmosses, gymnosperms, monocotyledons and dicotyledons.

   Observe spores of fungi, moss and fern. Discuss the roles of spores and seeds in dispersal and reproduction. Call attention to veins in leaves and vascular bundles in stems. Compare a moss plant with a spike moss plant (Selaginella). Which has true leaves and vascular bundles? Let pupils attempt to group the plants on the basis of whether or not they produce seeds, whether or not they possess vascular bundles, whether or not they possess green chlorophyll, and any other conspicuous differences they may observe.

   After the main groups have been organized and agreed upon, list the important characteristics of each group on the blackboard. If mistakes have been made in including one or more specimens in a group where they do not belong, make the correction by asking questions so that the pupils can correct their own mistakes.

Suggested Activities (continued)

After pupils have checked their groupings by reading in textbooks and references, have them list the name, structural characteristics, and examples of each group. Record in data books. More detailed information derived from further reading can be added later. Introduce a discussion of the derivation and uses of scientific names.

2. Detailed Study of the Major Plant Groups

Use the terminology and system of grouping found in the text that is available to your students. Discuss the reasons for disagreement on the details of plant classification. Discuss what is meant by simple plants and complex plants. Arrange the named groups of plants in order from the most simple to the most complex.

Algae: Examine several species of algae macroscopically and microscopically. Living specimens of fresh-water algae and living or dried or preserved species of marine algae should be used. Explore such topics as algae as a source of food for aquatic organisms, algae as food for man, the Sargasso Sea, the giant sea kelps, marine algae and reef formation, algae in contamination of drinking water.

Fungi: Since most fungi are not green, and since those that are green do not contain chlorophyll, raise the question as to their source of food. Discuss the terms saprophyte, parasite, heterotroph, and autotroph.

Grow different kinds of molds and examine them under the microscope for mycelium and spores. Study mushrooms, shelf fungi, puffballs, and some parasitic fungi, such as apple rust and black spot on roses. Discuss fungi as the source of penicillin and other antibiotics.

Lichens: Discuss the mutualistic association between the algal and fungal components of lichens. Examine portions of moist, living lichens and attempt to recognize the algal and fungal components

Study several available kinds of lichens. Point out the three general types: crustose, foliose and fruticose. Have one or more pupils report to the class on the pioneering soil-forming roles of lichens on bare rocks.

Mosses (Bryophytes): If a terrarium is available, several species of moss should be collected and kept fresh in plastic bags until time for study. Have the pupils study a typical moss plant and label the different parts. The roles of sporophytes and gametophytes should be discussed. Raise such questions as: Where are moss plants usually found? Why? Volcanic islands far from the mainland are usually occupied first by algae, lichens, mosses and ferns. Seed plants come later. Why? Discuss the economic importance of mosses. How do they compare in economic importance with algae and fungi?

Tracheophytes: Study ferns, gymnosperms and angiosperms. Place a celery leaf or a shoot of Impatiens in colored water to demonstrate the presence of vascular bundles. Emphasize that this specialized conducting tissue gives the name to the Tracheophytes.

Suggested Activities (continued)

Ferns: Eight or ten common species of ferns should be available. Label the different species with their common name. Have the pupils list the ways in which each species is different from the others.

Call attention to fertile and sterile leaves, the position, shape and size of sori, and the general shape of leaves -- whether simple and entire, lobed, once - twice - or thrice - pinnate. Have the pupils construct a simple dichotomous key whereby each species can be identified.

Call attention to true roots, stems and leaves. How do these differ from the "leaves" of moss and the rhizoids of moss? The reproductive cycle of ferns will be studied later.

Gymnosperms: Gymnosperms are generally available all year round. Study several species with their cones. Ginkgo and yew do not produce cones and the cone of juniper is so rounded and compressed that it looks like a blueberry.

Have the pupils construct a simple key capable of identifying six to ten species of gymnosperms. Give special attention to needle or leaf shape and size, number of needles or leaves in a cluster, the size and shape of the cone or other seed-bearing structure. If possible, use color slides or pictures to supplement observations.

Angiosperms: The two major subgroups of angiosperms, the monoctyledons (grains, grasses, palms and lilies) and the dicotyledons (most broad-leaved species) should be illustrated with examples of several families belonging to each subgroup.

Diversity within a pattern of similarity is characteristic of all parts of plants. These differences are usually associated with functional adaptation to the habitat. The whole class should be involved in collecting and displaying different kinds of root systems, different kinds of leaves and leaf arrangements, different forms of stems, and several different types of flowers. Have these brought to the class before the following studies are begun.

Roots: Display for study plants having fibrous roots, fleshy roots and woody roots. Distinguish between roots and underground stems. Why is it said that a white potato is a stem while a sweet potato is a root? Make a cross section and a longitudinal section of a carrot root to demonstrate the different parts of a root. Germinate corn kernals and onion seeds to further illustrate the different regions of a root and the nature of root hairs. Examine root hairs under a microscope. Discuss their function.

Stems: Compare the functions of stems with those of roots. Observe several types of stems: tubers, runners, rhizomes, corms. Have the pupils observe and sketch the parts of a woody stem: nodes, internodes, terminal bud, lateral buds, leaf scars, stipular scars, lenticles. Show them how the presence of terminal bud scales can be used to determine the age of a young woody branch. Examine cross sections of woody stems, identifying annual rings, xylem, phloem, xylem rays, pith, cortex and epidermis. Discuss evidences for the function of these parts. Have pupils suggest experiments by means of which functions of different tissues could be established. Have these experiments performed by small groups and demonstrated to the class. Discuss man's use of stems for food, paper, building materials and other uses.

Suggested Activities (continued)

Leaves: Observe blade, petiole, and sheath and stipules where present. Contrast different kinds of venation (parallel, pinnate, palmate and dichotomous) and different kinds of leaf margins. Compare simple and compound leaves. Observe a cross section of a leaf under the microscope. Identify the principal parts. Further consideration of photosynthesis will follow the study of the flower.

Flowers: The flowers of several different species should be obtained and distributed in the classroom so that each pupil or study group has flowers of several species. Several species, such as Gladiolus, are obtainable throughout the year. Some pupils may be able to bring suitable flowers from their homes.

Using a relatively large flower, observe and indicate the names of the different parts. How can sepals be distinguished from petals? Do all flowers have sepals, petals, stamens and one or more pistils? If possible, have the pupils observe one or more *imperfect* flowers. Call attention to the existence of *monoecious* and *dioecious* species. Provide an illustrative example, if possible.

Choose one species and list in the data books the number of sepals, petals, stamens, and pistil(s) for that species. Prepare a table like that given below on the blackboard and record pupil observations for several species in the table. Have pupils check their observations and then record the table in their data books.

COMPARISON OF SOME FLORAL CHARACTERS
(Similarities and Differences)

Species Characteristics		Species Names								
		1	2	3	4	5	6	7	8	9
Number of	sepals									
	petals									
	stamens									
	pistils									
Petals	united									
	separate									
Flowers	regular (actinomorphic)									
	irregular (zygomorphic)									
Position of ovary	above petal attachment (superior)									
	below petal attachment (inferior)									

Suggested Activities (continued)

Extending Knowledge for the Interested Pupil: Following are several projects and investigations from which the teacher may choose certain activities for the class as a whole, but they have been selected especially for those students interested in pursuing topics or ideas in which they have developed special interests.

Projects

Plants used for medicinal purposes
Preparing and maintaining a saltwater aquarium
Making an insect collection
Insectivorous plants
Preparing and maintaining an ant collection
Making spore prints of mushrooms
Poisonous animals
Poisonous plants
Orchid culture
Collecting, culturing and pressing ferns
Culture and observation of meal beetle larvae
Culture of molds on artificial media
Isolating and raising pure cultures of microorganisms
Collecting and caring for frogs
Collecting and displaying insect galls
Developing and organizing a shell collection
Preparing and displaying vertebrate skeletons

Investigations

Experiments with protozoa
Reactions of hydra to various stimuli
Responses of plants to light
Responses of animals to light
Use of albino and normal corn seedlings to show where plants get energy and materials for growth
Regeneration in planaria
Comparison of the mouthparts of a grasshopper and a mammal
How plants respond to gravity
How animals respond to gravity

Suggested Activities (continued)

3. No attempt will be made at this point to introduce all of the important processes which take place in plants. The junior high school student does not have the background in chemistry and physics to understand the details of these processes. However, an equation expressed in words instead of formulae can be used to represent the main substances and conditions involved.

REACTANTS	CONDITIONS	PRODUCTS
water + carbon dioxide	{in the presence of light and chlorophyll} ----->	sugar + oxygen

The importance of photosynthesis as the source of food and atmospheric oxygen should be emphasized. Have the students participate in setting up the experiments. See references 9 and 11.

Utilization of carbon dioxide and water in photosynthesis: Secure two healthy plants as nearly alike as possible and number them I and II. Water each one with equal amounts of water and cover the soil with aluminum foil to prevent loss of water from the soil. Cover plant I with a bell jar. Immediately place a shallow dish of freshly prepared filtered limewater under the bell jar beside the plant and place the whole apparatus in a dimly lighted part of the room. Observe for any change. Limewater should turn milky showing the presence of carbon dioxide. Cover plant II with a bell jar and leave for several hours in the sunlight.

Carefully place under the jar beside the plant a shallow dish of freshly prepared filtered limewater. Observe. The limewater should remain fairly clear. Discuss the use of carbon dioxide and water by the plants. The presence of the water on the jar indicates that water is involved in the process. See references 9 and 11. (Concepts 6, 9)

Have the pupils interpret the results of this experiment. How can it be demonstrated that the milky color in the limewater was produced by the reaction of carbon dioxide with limewater?

Oxygen in photosynthesis: Secure another healthy plant. Place a bell jar over it. Insert under the jar a glowing matchhead. Record results. After several hours, have the same student insert another glowing matchhead. It should glow brighter. (This is the test for oxygen.) The composition of the air has obviously changed. This should lead to a discussion of oxygen and the fact that it must have been produced by the plant.

Oxygen can also be collected from aquatic plants by inverting a funnel over the plants and placing a test tube over the end of the funnel. The gas can be tested by inserting a glowing matchhead. See reference 12, 13, and 14.

Manufacture of food: Give directions for covering one or two leaves of a plant with black paper. Place the plant aside for several days. At the end of that time, take Leaf I (exposed to light) and Leaf II (covered with black paper) and record the appearance of both. Number II should be pale and decidedly lacking in chlorophyll. It should also be noticed that light could not get to the leaf.

Suggested Activities (continued)

Give clear directions for extracting the chlorophyll. The teacher should supervise the process. Use alcohol in beakers. Have beakers placed in a water bath. Do not use a direct flame on a beaker of alcohol. See references 12 and 14.

Following this treatment, test each leaf for the presence of starch. Place a drop of iodine solution on each leaf. The leaf exposed to the light (control) should give a positive reaction (dark blue color). The experimental leaf should give a negative reaction. It should be made clear that glucose is the product of photosynthesis but energy is stored as starch in the leaves. See references 12 and 14. Concepts 8, 9, 10 and 11.

Emerging Concepts

1. The most common characteristic of plants is that they are green. The color is due to a pigment called chlorophyll. Chlorophyll is necessary for the process of photosynthesis.

2. Within the plant kingdom there is a great range of diversity.

3. Plants which share certain common similarities are placed in taxonomic groups or levels.

4. A greater range in diversity exists in the major groups, more similarity in the smaller, more specific groups.

5. The scientific name of an organism is derived by combining the genus name and the descriptive term or specific epithet.

6. Green plants take carbon dixoide from the air and water from the soil during the process of photosynthesis.

7. Green plants release oxygen during photosynthesis.

8. Sunlight is necessary for the process of photosynthesis. Without sunlight, chlorophyll does not develop. Without these two factors, photosynthesis does not occur.

9. Water and carbon dioxide are taken into the plant and in the presence of chlorophyll and sunlight yield glucose (sugar) and oxygen.

10. Through a series of complex steps, green plants change glucose to starch.

11. The climax of the study results in the following: Sunlight is a form of energy. Plants actually capture energy from the sun and incorporate it into food, thereby making energy available to animals. This is the only way that energy enters the world of living things. Consequently, animals are dependent on plants for energy in foods.

Equipment

Four growing plants of the same species and as nearly alike as possible (geranium, tomato, bean, or other suitable plants), bell jars, shallow dishes, limewater tablets or calcium hydroxide, funnel, test tubes, wood splints, black paper, solution of iodine or iodine and potassium iodide, 250 ml flasks, aluminum foil, rubber or cork stoppers

Other Aids

A set of filmstrips, transparencies, or slides of a variety of representatives of the plant kingdom

Models of flowers and other plant structures

Films

1. *Simple Plants: Algae and Fungi*, j-s, 18 min., 4178
2. *Simple Plants: The Algae*, j-s, 20 min., 5392
3. *Leaves*, j-s, 128
4. *Simple Plants:* Bacteria, j-s-c, 14 min., 4192
5. *Trees: How to Identify Them*, e-j, 11 min., 1838
6. *Life Story of Fern*, United World Films, N. Y.
7. *Classifying Plants and Animals*, Coronet Films

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UNITY AND DIVERSITY AMONG THE PROTISTS

Introductory Material

To implement the study of the protists, the use of the microscope may be introduced. The material such as the pond water that has been previously collected may need to be supplemented in order to assure the presence of the protists for this investigation. Culture some organisms or purchase them from a supply center. If this is not possible, it is suggested that films or filmstrips be used to show protists as they appear under the microscope. As a reminder to teachers, consideration should be given at this time to insuring that the proper materials or equipment, such as slides, are available or can be made available for the teaching of Unit III. See references 7 and 8

Suggested Activities

1. A Study of the Microscope: Make a simple introduction to the microscope, its major parts and their uses. (The depth and breadth for this study should be determined by the teaching condition.) If only a few microscopes are available, it may be necessary for teachers to use the instrument for demonstration purposes only. See references 7 and 8. (Concept 1)

2. A Study of Bacteria: Bacteria: Bacteria are universal and can be collected from a variety of sources-water, soil, air. To culture bacteria, place a small number of bean seeds in water and allow them to stand for three or four days. Simple microscopic slides of the bacteria may be prepared by placing a drop of the growth medium in water on a slide and covering with cover slip. Observe and study specific characteristics such as size, color and shape. A study of the conditions essential for the growth of bacteria, such as temperature and light, could be conducted. An advanced student may study the effect of antibiotics on bacterial growth. (Concept 2)

3. A Study of Some Protozoa (Flagellates, Sarcodinans and Ciliates): Examine a hay infusion culture and pond water for the presence of protozoa. The cultures should be examined in advance by the teacher to be sure of the presence of the desired protozoa. If the above two sources fail to provide the desired protozoa, it might be necessary to purchase these protozoa, to use textbook diagrams and to show films or filmstrips. No attempt should be made at this time to key the

Suggested Activities (continued)

protozoa. Merely observe their similarities and diverse adaptations and point out that these protists are composed of one unit, the cell. Students should make simple structural sketches of the protozoa as they are observed. To aid the student in identifying the organisms, use illustrations. See references 7 and 8. Film 5. Concept 3

4. A Study of the Cell: The organisms previously studied were unicellular organisms. "Would this be true of all living organisms?" From the variety of responses to your question, the students may be guided into further study.

   Prepare microscope slides of a piece of onion skin, scrapings from the lining of the cheek, and elodea leaf. Examine and sketch in data book. Compare these cells with the protozoan cells. Variations and similarities found should be listed by each student in his data book. Dye the onion slide with iodine and the cheek cells with methylene blue solution. Observe and sketch. Identify the nucleus, cytoplasm and cell membrane. The nucleus and cytoplasm of many parts will be discussed in later studies. See references 7 and 8. Concepts 4, 5, 6, and 7

Emerging Concepts

1. The microscope aids our senses in learning more about our living world.
2. Bacteria are protists which show diversity in size and shape.
3. Protozoa are protists which show diversity in size, shape and methods of locomotion.
4. Bacteria and protozoa are unicellular organisms.
5. Living organisms are both unicellular and multicellular.
6. The cell unit is composed of three basic parts: nucleus, cytoplasm and cell membrance.
7. Plant cells have a cell wall and contain a green material in structures called chloroplasts, located in the cytoplasm.

Equipment

Culture of protozoa, bacteria, blank slides, cover slips, bean seeds, microscopes, onion, elodea, iodine solution, methylene blue

Films

1. Life in a Pond, e-j-s, 11 min., 1026
2. Protist Kingdom, The, j-s, 14 min., 4278
3. Amoeba, j-s, 11 min., 1591
4. Bacteria, e-j-s, 11 min., 797

Films (continued)

5. Life in a Drop of Water, e-j-s, 11 min., 417
6. Microscopic Wonders in Water, e-j-s, 11 min, 1207
7. Tiny Water Animals, e-j-s, 11 min., 217

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INTERPRETATION OF THE ORIGIN AND SIGNIFICANCE OF THE GREAT VARIETY OF TYPES WITHIN BROADLY SIMILAR GROUPS

Introductory Material

The foregoing studies should have led the students to become conscious of the great variety of types within broadly similar groups of organisms. They may have become aware also that many variations or differences represent adaptations or combinations of inherited characteristics that improve an organism's chance to survive and reproduce in a particular environment.

How did these adaptive variations come about? The old answer was that all types of organisms were originally created with the same characteristics they have today, and that they have remained that way since their creation. But different breeds of chickens, dogs and cattle, as well as different varieties of fruits, grains and vegetables, have risen within historical times, showing clearly that the types of populations we call kinds or species of organisms do not remain constant and unvarying.

Have the students name other examples of new and different kinds of organisms that have arisen within the last several hundred years.

At this age level students are fully aware of certain abnormalities that occur in various organisms - two-headed calves, three-legged chickens and thalidomide-affected babies. These are differences that are not passed on from generation to generation. Have the students list examples of conditions that are passed on generation to generation.

Without going into the nature of genes and gene mutations, point out that new, heritable changes do occur from time to time, and that changes that result in survival advantages are passed on from generation to generation more often than the original condition they tend to replace. It has also been shown that the rate at which new heritable changes occur can be greatly increased by the use of X-rays and other types of radiations as well as by the use of certain chemicals.

Most modern biologists agree that certain events must take place and certain conditions must prevail in order that two or more kinds of organisms (species) may arise from one original kind. First, two or more populations become isolated by barriers such as mountains, deserts, oceans or barriers to interbreeding. Second, as a result of a long period of reproductive isolation, each population accumulates different sets of heritable differences (mutant forms), and third, the isolated populations finally become so much different that interbreeding is impossible if they are again brought back together. In other words, two or more kinds or species have arisen from one original type.

Have the students give examples of white species that have arisen in the colder parts of the continents, of cave-dwelling blind animals, and other examples of change that takes place with isolation of species.

Suggested Activities

1. Examples of Adaptations

Organisms that cannot adjust to a changing environment do not survive in competition with those that do. Adaptations are the result of hereditary changes.

Organize a study of adaptations around two or more of the following adaptations:

Mimicry: Example: Viceroy and Monarch butterflies, Walking Stick, Carpenter Bee and Bumblebee

Adaptations of desert plants: Cacti or various species of Euphorbia

Protective coloration

Animals with electric organs

Cyst formation

Spore formation

Behavior patterns: Birds, insects, reptiles

2. Survival of two types (Phenotypes and Genotypes) of Fruit Fly (Drosophila) in Competition With Each Other

Two kinds of fruit flies, the wild type with normal wings and mutated flies with vestigial wings, will be used. Both wing types are inherited. Flies of these two types may be obtained from biological supply houses or from most colleges and universities.

Following standard procedures for etherizing flies, select five males and five females (less than 10 hours old) from each stock bottle and place them together in a population jar well stocked with *Drosophila* food.

After several weeks, etherize and study the resulting population following standard procedures. Sort the flies into the two groups (normal and vistigial). Determine the percentage of each type. Is there any change in percentage from the original population of 20 flies?

On some small Pacific Ocean islands practically all of the insects are flightless (either without wings or with vistigial wings). Explain.

3. Fossil Plants and Animals

Fossil remains of plants and animals have been found in abundance at various places on the earth. In some instances the fossils found at these sites differ from any living creatures. Have the students prepare reports on such areas as the Dinosaur National Monument in Utah and Colorado, the Fossil Cycad National Monument in South Dakota, the Petrified Forest National Monument in Arizona, and the LaBrea Tar Pits near Los Angeles. Ask the students to account for the fact that many of the ancient plants and animals now found as fossils are sharply different from somewhat similar forms living today.

Suggested Activities (continued)

4. Fossil Ancestors of Modern Mammals

   Several well documented series of fossils have been assembled to illustrate the gradual and progressive changes that have taken place during the hundreds of thousands of years in the development of modern elephants, camels and horses. Have the students prepare charts showing these changes. Have the students explain the processes or mechanisms which have brought about the changes illustrated.

5. Methods of Estimating the Age of Fossils

   Determining the age of fossils has always posed problems. The use of radioisotopes, such as carbon-14, discovered comparatively recently, has provided far greater accuracy in estimating the age of fossils than was previously possible. Have some of the students prepare reports on the use of radioisotopes and other methods to determine the age of fossils.

6. Adaptations in Skeletal Development

   Have students compare the skeleton of a bird with that of a mammal, such as a dog or cat. These skeletons can be obtained from supply houses, or they can be prepared by the students themselves. If skeletons are not available, good charts may be substituted. List the more obvious skeletal modifications or differences and show how each is advantageous to the species involved.

Emerging Concepts

1. All living things exist as populations of highly similar individuals. These populations of similar individuals are called species.

2. Species tend to remain the same generation after generation.

3. Despite the tendency to remain the same, species do change over a log period of time and many generations.

4. Although all individuals of a species are very similar, in every speies there are many heritable variations.

5. Changes in populations or species are partially the result of the occurrence of random heritable variations that take place in individuals. Heritabe changes in individuals result from chance changes (mutations) in the DNA (deoxyribose nucleic acid), the hereditary material of the cells.

6. Because the changes in DNA are passed along to offspring during reproduction, they are hereditary.

7. If mutations produce changes that help organisms to live and have ofspring, the mutated organisms tend to reproduce and increase in numbers more rapidly than competing, unmutated organisms, thus bringing about a gradual chang in the population. This process is called natural selection.

Emerging Concepts (continued)

8. An inherited variation or combination of characteristics that improves an organism's chance to survive and reproduce is an *adaptation*.

9. Units of heritable material that produce hereditary characteristics are called genes.

10. Biologists think of all the genes of a population or species as being present in a large gene pool.

11. If similar populations become isolated, thus decreasing the chance of gene exchange, the isolated populations tend to become more and more different with the passage of time.

12. The hypothesis that evolutionary change takes place over a long period of time through variation and natural selection was first clearly proposed by Charles Darwin in 1859.

13. All living things have developed from common ancestors through a gradual process of diversification and change called evolutionary change, according to the *theory of organic evolution*.

14. Evolutionary change through time has resulted in great diversity, but the common origin of diversity is reflected in the existence of a relatively small number of unifying basic patterns.

Equipment

Cultures of normal wild *Drosophila* and vestigial wing Drosophila, Culture bottles for *Drosophila* and Drosophila culture medium, ether and an anesthetizing bottle and funnel, *camel hair* brush, filter paper, petri dish cover

Films

1. *Adaptations of Plants and Animals*, e-j, 14 min., 4136

2. *Darwin's Finches*, Film Associates of California, Los Angeles, Calif.

3. *The Fossil Story*, Shell Oil Co., Film Library, New York 22, N. Y.

4. *Fossils: Clues to Prehistoric Times*, e-j, 11 min., 1879

5. *Life, Time, and Change*, Part X, *AIBS Film Series in Modern Biology*, McGraw-Hill, New York

6. *Prehistoric Times: The World Before Man*, e-j-s, 11 min., 1600

7. *Prehistoric Animals of the Tar Pits*, e-j-s, 15 min., 4682

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PROBLEMS AND PRINCIPLES CONCERNED WITH THE NAMING AND CLASSIFICATION OF LIVING THINGS

Introductory Material

Some of the earliest attempts at classification of plants and animals certainly took place before the dawn of history. During the fifth century B. C., Aristotle and Theophrastus classified and named approximately 1,000 species of plants and animals. The plant and animal kingdoms had long been recognized, but little was known of forms that do not fit exactly and convincingly into these groups. Theophrastus found that the older system of classification did not adequately separate and distinguish among the relatively few species of organisms known at the time. Today the task of classification is much more difficult. To clearly separate and then to group the nearly two million living species now recognized is a most difficult and time-consuming undertaking. Classification implies both relationship and change.

Introductory Material (continued)

It assumes that most of the points of similarity among organisms indicate relationship, and that the first living things were few, simple and similar. With the passage of time, these early forms became more complex, more abundant and of more different kinds.

At the time of Theophrastus, the plant and animal kingdoms were recognized, but organisms were classified as to habit, size, or habitat. Plants were classified as herbs, shrubs and trees, with vines and under-shrubs sometimes included. Animals were classified on the basis of habitat. "Land creatures" and "sea creatures" were the two recognized major divisions of animals. Almost anything that lived in the sea was considered a fish.

The following exercises are designed to make the students aware of earlier problems of classification and some of the problems and principles of modern taxonomy.

Suggested Activities

1. Exercise to Show that Classification by Habitat is "Artificial" in that it does Not Reflect True Relationship Based Upon Common Ancestry

   Have the students compile a list of "sea creatures" or aquatic organisms that are popularly called fish but which are not fish. To get started you may choose to write on the blackboard a randomised, combined list of fish and non-fish and have the students strike out the names of those that are not really fish. For example, sunfish, catfish, kettlefish, jellyfish, codfish, crayfish, silverfish, swordfish, starfish, shellfish, blackfish and dogfish. In each case have the students justify the removal of each name removed from the list. Have them consult a good dictionary or one of the references at the end of the section. What is a fish?

2. Interpretation of Similarities and Their Value in Classification

   In 1843 the famous British anatomist, Richard Owen, recognized that certain similarities in animals are "more fundamental" than others. Later, he recognized that these similar structures had common origins.

   Homologous structures: Have the students study two or more skeletons (or charts of skeletons) chosen from the following: cat, dog, bat, chicken, whale, seal or rabbit. Have them identify bones in the different skeletons that are similar in relative position, structure and number. Color corresponding (homologous) bones the same color in all sketches.

   The flipper of a whale, the wing of a bird and the arm of a man do not at first seem to have much in common, yet a careful study will reveal that the three apparently different structures possess modifications of the same basic bone pattern or arrangement. Such structures are thought to be similar because they originated from the same structure in a remote ancestor. Structures that are thus similar because they originated from the same stock are said to be homologous. Homologous structures are used more than any other features in classification.

Suggested Activities (continued)

Analogous structures: Have students compare the specimens or drawings of the leg of an insect and the leg of a cat, the wing of an insect and the wing of a bird. How do they compare in function? How do the two types of wings compare in structure? Such structures or organs that show superficial resemblance and function similarly, but which are constructed on totally different plans are said to be analogous. Differences in basic structure indicate different origins.

Have the students make a list of other homologous organs or structures. Prepare a similar list of analogous organs. Ask the students to account for the development of these two types of organs on the basis of evolutionary change. Which would be more valuable in classification, homologous structures or analogous structures? Why?

Emerging Concepts

1. Certain systems of classification may be useful in grouping organisms according to habitat, how they obtain their food, or their color. Grouping based on such characteristics is said to be artificial because it reflects no true relationship among members of a group thus established.

2. Early attempts to group and classify organisms were unsatisfactory because they did not indicate hereditary relationships among members of a group.

3. Modern systems of classification attempt to group organisms on the basis of those characteristics that most clearly and accurately indicate actual relationship.

4. Similarity between structures of different organisms due to the inheritance of the structure from a remote common ancestry clearly indicate relationship. Such structures are said to be homologous.

5. When structures that are not inherited from a common feature in the same ancestry are used by their possessors in similar fashion, the structures are said to be analogous. Analogous structures do not indicate genetic relationship from common ancestry.

6. One of the important problems concerned with the naming and classification of living things is that of determining which characteristics indicate actual relationships and which do not.

Films

1. Animals with Backbones, e-j, 10 min., 1872

2. Diversity of Animals, (set of 12 films, 28 min. each), Part VIII of AIBS Film Series in Modern Biology, McGraw-Hill, New York

3. Natural Selection, s, 16 min., 3412

References

1. Andrews, R. All About Whales.
2. Darby, G., What Is a Fish?
3. Deletoryas, T., Plant Diversity.
4. Hanson, E., Animal Diversity.
5. Fitzpatrick, F. and J. Hole, Modern Life Science.
6. Frasier, R. and H. Smith, The Biological Sciences, Investigation of Man's Environment.
7. Simpson, G. and W. Beck, Life: An Introduction to Biology. (Chapter 18, 21, and 22)
8. Yapp, W., Vertebrates: Their Structure and Life.

UNIT III. THE HUMAN ORGANISM

INTERRELATIONSHIPS OF STRUCTURE AND FUNCTION

Introductory Material

People are organisms. If all living things were totally different from each other, it would be hard to make sense of the bewildering diversity. However, people can see in themselves many of the characteristics shared by other animals. People are higher vertebrate animals in having backbones, legs, a head with eyes and ears and a mouth at the fore part of the body. We have bones, blood, hair and a need for food and air as other animals do.

As every student who has taken a clock or a simple engine apart realizes, there is an obvious and interesting relationship between physical make-up (structure) and the way that structure works (its function). In living things, structure and activity are so closely interrelated that it is almost impossible to think of one without the other. When we say wing, we think of flying; when we say eye, we think of seeing.

The purpose of this unit is to give students an opportunity to gain a better understanding of the structure of their own bodies and how structure is related to many coordinated and interrelated functions. Chemical formulas and equations should be kept at a minimum. Otherwise, attention is likely to be diverted to memorizing equations and formulas rather than understanding how the body is constructed and how this structure is intimately related to functions.

An understanding of activities or functions necessitates an introduction to the concept of energy. Fortunately, the scientific meaning of energy is about the same as the popular meaning. Energy is the ability to do work. We speak of the potential energy of water as it falls toward the water wheel, and we know something about electrical energy, heat energy. All living things reproduce themselves and obtain chemical energy from the molecules that they take in from the environment.

The sun is directly or indirectly the source of all energy. The green plant traps the energy of the sun during the process of photosynthesis and stores it as chemical bond energy in the nutrients. Glucose, a simple sugar and the product of photosynthesis, is the building block of all carbohydrates. Carbohydrates are converted into glucose during digestion providing the source of energy in man. Concepts 1 and 2.

Suggested Activities

1. Human Eye

   Compare a model of the human eye with a camera, stressing particularly structure, the pathway of light, the function of the lens, the iris diaphragm, and the formation of the image.

Suggested Activities (continued)

Modern Physical Science-page 328. Modern Science: Man, Matter, and Energy-page 130.

2. Human Ear

Study models or illustrations of the human ear. As each structure is considered, point out its role in the hearing process. Compare the ear of a person with that of a frog. What advantage or disadvantage is there in the difference? What are the advantages of the relatively large ears of a fox or a rabbit?

3. The Digestive System

Composition of Carbohydrates: Put about a teaspoon of sugar in an evaporating dish; support on ringstand and heat. Hold a cold glass dish above the dish of sugar. What is formed on the dish? (Water will condense on the dish). Water is composed of what two elements and in what proportions? (Two parts hydrogen to one part oxygen). Continue to heat the dish of sugar until no moisture comes off. What is left in the dish? (a black substance, carbon). Concept 3.

Test for sugar and starch: See reference 24, p. 295, and reference 23, p. 158. Concept. 3

Test for fat: See reference 23, p. 158. Concept 4

Test for proteins: See reference 23, p. 159. Concept 5

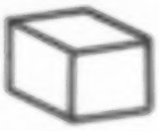
Textbooks on life science: These cover material on nutrients including the above, as well as minerals and vitamins. Concepts 5 and 6

Film on nutrients and their uses: See film 11. Concepts 5 and 6

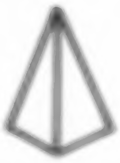
Organs of Digestion. Life science texts cover this material thoroughly. Use models, charts and transparencies to make the study interesting.

Process of Digestion: Why is digestion necessary? Construct the following objects of cardboard. A and B are solid objects. C is an empty box. The box is completely enclosed but the walls have many small round holes. These holes cannot be made larger. Problem: How can you move the materials in object A and B into Box C?

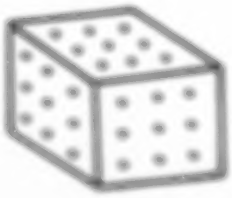
A



B



C



Suggested Activities (continued)

(It is obvious that A and B must be broken down into smaller parts. Cut A and B small enough to get into holes in box C.) Concept 7

Action of ptyalin on starch: See reference 23. Concepts 7, 8 and 9

Action of pepsin on proteins: See reference 23, p. 170. Concepts 7, 8 and 9

Films 9 and 11. Concepts 7, 8 and 9

Absorption of digested foods: An experiment on osmosis found in many biological sourcebooks could be used since this is the type of diffusion by which nutrients pass from the digestive tract into the blood stream. Reference 1 and 3,Concept 10

Prepare a nutrient solution as follows: 100 ml. water, 1 tbsp. glucose, a tbsp. corn starch, 1 tbsp. Wesson oil (fat).

Secure a piece of sausage casing or cellophane tubing, 3/4 in. diameter, about 12 in. long. Tie one end securely with a piece of string. Now fill the casing or cellophane tubing about 1/2 full of the solution. Use a medicine dropper and be very careful that there is no nutrient on the outside of the casing or tubing. To be sure there is none on the outside, wash off the tubing well. Tie the second end tightly with a string before washing. Suspend as shown in a beaker of warm water (34-40 degree C.) Let this stand for about 10 min. and test the water in the beaker for proteins, fats, starch and glucose. Concept 11

4. The Circulatory System

Place a stained smear of human blood under high power of a microscope. Allow students to observe and sketch in their data books. Smear may be secured from a doctor or a hospital if one is not available in your school. Concept 12

All life science texts have a section on blood. Use effectively. Concept 12

Transparencies and charts are available.

Film. First part of "Hemo, The Magnificent." Concept 12

The Blood Vessels: From textbooks, transparencies, and charts, students should be made aware of the three types of blood vessels, their structure and function (Arteries, veins, capillaries) Concepts 13, 14 and 15

The first activity under Circulation of blood above may be used while studying blood vessels, if the teacher desires.

The Heart: Using a model of a heart, point out the four chambers, the valves, the vessels leading into and out of the heart and wall thickness.

Excellent work sheets of the heart can be secured free from the Georgia Heart Association, Atlanta, and would be good to use in connection with the study of the model. Parts could be appropriately colored, labeled, and arrows used to show circulation of blood through the heart. Concepts 16 and 17

Suggested Activities (continued)

Observation: Reference 24. Study of cow or pig or chicken heart. Concepts listed above.

Circulation of Blood: Observation--Reference 24. Circulation in a fish tail fin.Concept 17

Free work charts for all classes can be secured from the Georgia Heart Association, Atlanta. These charts can be appropriately colored and arrows added to show the course of the blood. Concept 17

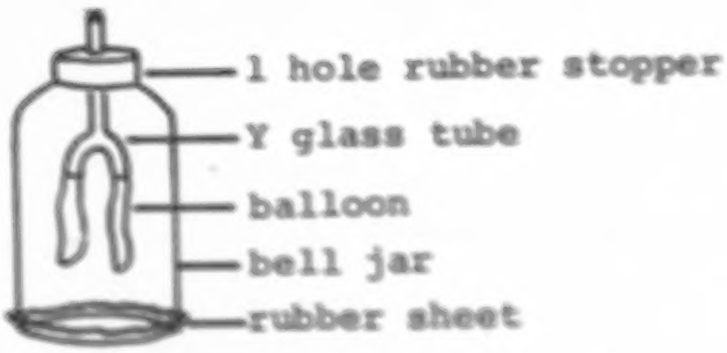
Pulse rate vs. heart beat. Appoint two students as timekeepers. Have each student extend his left arm, palm up, on the top of his desk. Each can feel his own pulse by placing the tips of the index and third finger of right hand on the underside of the wrist near the base of the thumb. Allow students to count their pulse for ½ minute and multiply by two to get the rate per minute. Let each student count his neighbor's pulse to check his count. Record in data book. Have students use stethoscope to count the beat of the heart per minute. Compare the heart beat with the pulse rate. (They should be the same). What causes the pulse? Record data. Concept 17

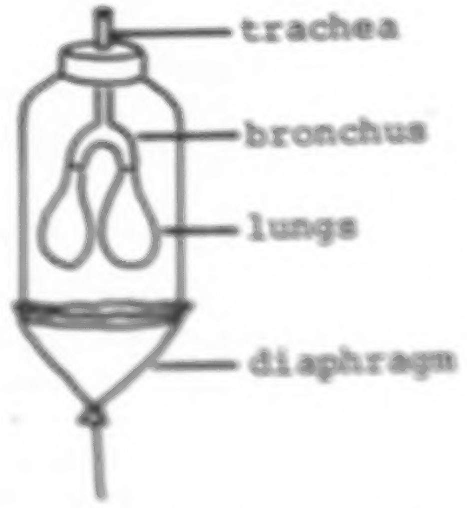
Show film, "Hemo, The Magnificent" (second part)

5. The Respiratory System

Organs of respiration (breathing): This study can be accomplished through the use of textbook, charts, models and transparencies. Concept 18

The Breathing Process: Construct an apparatus as shown in the following diagram.





What happens when the rubber sheet is pulled down? Pushed up? Record results. Concept 19

Allow the student to count his breathing rate per minute. Have a student run in place or take some type of exercise and count his breathing rate. Record results. Concept 19

Suggested Activities (continued)

Explain in a simple way oxidation in cells and aerobic respiration. The following activities are to be done at the proper time during the teacher's explanation.

Have a student blow bubbles through straw into limewater. The limewater becomes milky, showing that carbon dioxide is given off in breathing.

Have a student blow his breath on a piece of glass. Note water formed. Concept 20

Use films 5 and 8.Concepts 18 and 19

6. The Excretory System

Excretion is the process of getting rid of waste produced in the body tissue. Feces, composed principally of undigested food, never enter the body tissue and are not considered true excretion. Feces pass from the large intestines. The excretory products are carbon dioxide, given off from the lungs, and water in which is dissolved nitrogen compounds excreted from the kidneys with related organs and the skin.

Observation: Examining a kidney. Reference 24, p. 331. Concepts 21 and 22

Textbook materials, charts, models and transparencies Concepts 21 and 22

Films on skin, kidneys. Concepts 21 and 22

Emerging Concepts

1. With the exception of atomic energy, all energy comes from the sun.
2. Energy is stored as chemical bond energy in nutrients.
3. Carbohydrates are composed of carbon, hydrogen and oxygen, and are the chief source of energy in living matter.
4. Fats are digested and used by the body as sources of energy in addition to carbohydrates, or instead of carbohydrates when the latter are not available.
5. Proteins are the most abundant carbon-containing compounds of the human body and of the bodies of plants and animals. Protein foods and minerals are used by the body in building body tissues.
6. For its normal regulation the human body needs vitamins produced mostly by green plants. Vitamins are special organic compounds needed to construct regulators of chemical processes of the body.
7. Foods must be broken down into smaller molecules before they can be used. Digestion is the process by which food materials are broken down into molecules simple enough to be absorbed and used by cells of the body.
8. Enzymes are protein compounds that increase the rate of chemical reactions within cells. Digestion is one of the many types of chemical reactions controlled by the action of enzymes.

Emerging Concepts (continued)

9. The process of splitting (digesting) a molecule by adding a molecule of water is known as hydrolysis.

10. Molecules and ions tend to move in all directions as a result of their own motion or of being hit by other molecules and ions. This movement is called diffusion, and eventually it leads to an even distribution of the diffusing substance.

11. A cell membrane allows certain materials to pass through it more readily than others. Such a membrane is called a selectively permeable membrane. The diffusion of water through a selectively permeable membrane is called osmosis. Molecules of materials dissolved in water may also diffuse through a membrane from a region of higher concentration to a region of lower concentration. Movement of materials in the opposite direction requires the cell to use chemical energy, and the movement is called active transport.

12. Larger animals require a method of movement of molecules faster than that of diffusion. In man and other higher animals transport is carried out by the circulatory system composed of the heart, arteries, veins, capillaries and blood. Blood is composed of plasma, red blood cells, white blood cells and platelets.

13. Arteries are the blood vessels that carry blood away from the heart. The arteries have a smaller inside diameter and thicker walls than the veins, thus the arteries are able to withstand greater blood pressures than the veins.

14. Veins are the blood vessels that carry blood back to the heart. The larger veins have valves spaced along their lengths that keep the blood flowing in one direction toward the heart. These valves act like one-way gates.

15. Capillaries, the most numerous and smallest of the blood vessels, connect the smaller arteries and the smaller veins. Blood flows from the arteries through the capillaries to the veins. Actual exchange between the blood and the individual cells of the body takes place through the capillary walls.

16. The human heart is a double pump composed of a right atrium and a right ventricle on one side and a left atrium and a left ventricle on the other. The upper chamber on each side, the atrium, has a thinner wall than the lower chamber, the ventricle. The heart beats in two steps. Contraction of the atrium forces blood between flap-like valves into the ventricle. Then muscles of the thick-walled ventricle contract to squeeze the blood forcefully into the arteries.

17. The function of the circulatory system is to supply all of the cells of the body with the materials necessary for life and to carry away waste products. To provide the billions of cells of the human body with these materials, the circulatory system is dependent upon the enormous area provided by the network of capillaries that extend into every tissue of every organ of the body.

18. Air enters the nose and passes through the pharynx (throat), glottis, larynx (voice box), trachea (windpipe), bronchi, and into the air sacs (alveoli) of the lungs.

19. When the diaphragm contracts and moves downward and the muscles between the

Emerging Concepts (continued)

ribs contract and bow outward, the chest cavity becomes larger, drawing air into the lungs. When these muscles relax, the chest becomes smaller and the air is forced out.

20. The blood carries food (glucose) and oxygen to the cells. Within the mitochondria (power houses) in the cytoplasm of the cell, oxidation of glucose occurs. Traditionally, the liberation of energy in organisms is compared to the production of energy in a gas engine. The energy from fuel in a gas engine is produced in a large amount. An organism could not handle this large amount of energy at a given time; therefore, the process is more gradual. Through a series of complex chemical reactions, glucose is broken down into carbon dioxide and water and enough energy is liberated to build 36 to 38 molecules of ATP (adeonsine triphosphate). ATP is the energy carrier present in all living cells and furnishes the energy necessary for all life activities. This is called aerobic respiration.

21. As the blood passes through the capillaries which form a network around the tubules of the kidneys, water with dissolved mineral salts, urea, and other nitrogenous wastes filters into the kidney tubules. This mixture is called urine. The urine is carried to the bladder through a tube or duct called the urethra.

22. The skin has many functions. Among them are: (a) sensation -- touch, heat, cold, pressure, pain. (b) protection; (c) regulation of temperature; (d) excretion of water with dissolved minerals and nitrogenous wastes. The structures studied in the skin are adapted to carrying on these functions.

Equipment

sugar, evaporating dish, ringstand, Bunsen burner, Fehling's solution, Benedict's solution, ammonium hydroxide, concentrated nitric acid, test tubes, test tube racks, eye dropper, spoon, cornstarch, clear Karo syrup or molasses, lard, butter or cooking oil, white paper, egg white, cardboard, 150 ml. beaker, sausage casing or cellophane tubing, Lugol's (iodine) solution, ptyalin, pepsin, string, stained blood smear, cow, pig or chidken heart, scalpel, stethoscope (or homemade with roll paper), 1 hole rubber stopper, Y-glass tube, balloon, bell jar, rubber sheet, kidneys (from meat market)

Other Aids

Film strips, transparencies, and model of human torso

Free work sheets from the Georgia Heart Association, Atlanta, and a prepared series of charts representing the individual body systems

Films

1. Circulation, United World Films, Inc. j-s, 18 min., 4203

2. The Ears and Hearing, j-s, 9 min., 425

Films (continued)

3. *The Eyes and Their Care*, j-s, 11 min., 269
4. *The Human Body: Excretory System*, j-s, 14 min., 4252
5. *The Human Body: Respiratory System*, j-s, 14 min., 4319
6. *The Human Body: Nutrition and Metabolism*, j-s, 14 min., 4317
7. *The Human Brain*, j-s, 11 min., 867
8. *Mechanism of Breathing*, j-s, 11 min., 234
9. *The Multicellular Animal*, (Set of 12 films, 28 minutes each), Part IV of *AIBS Film Series in Modern Biology*, McGraw-Hill Pub. Co., Text Film Div., 330 W. 42nd St., New York 36, N. Y.
10. *Muscles and Bones of the Body*, Coronet Instructional Films
11. *Nutritional Needs of Our Bodies*, e-j, 11 min., 1746
12. *The Skeleton*, j-s, 12 min., 669

References

1. Brooks et al., *Modern Physical Science*.
2. Blanc, S. S. et al., *Modern Science: Man, Matter, and Energy*.
3. Miller, D. and G. Blaydes, *Methods and Materials for Teaching the Biological Sciences*.
4. Morholt, E., et al, *A Sourcebook for the Biological Sciences*.
5. Mickelsen, O., *Nutrition, Science, and You*.
6. Nourse, A., *Body*.
7. Asimov, I., *Life and Energy*.
8. Asimov, I., *Chemicals of Life*.
9. Berger, A., *Elementary Human Anatomy*.
10. Best, C. and N. Taylor, *The Human Body*.
11. Carlson, et al, *The Machinery of the Body*.
12. Fitzpatrick, F. et al, *Living Things*.
13. Fleck, H. and E. Munves, *Introduction to Nutrition*.
14. Glemser, B., *All About the Human Body*.
15. Guyton, A., *Function of the Human Body*.

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16. Haag, J. and D. Vere, Physiology.

17. Mason, J and R. Peters, Life Science.

18. McNaught, A. and R. Callender, Illustrated Physiology.

19. Schlost, G., Your Wonderful Teeth.

20. Nasset, E., Your Diet, Digestion, and Health.

21. Schneider, L., Lifeline: The Story of Your Circulatory System.

22. Turtox Biological Supplies, General Biological Supply House, Inc., 1968-69, 8200 S. Hoyne Ave., Chicago, Ill.

23. Wailes, J., Living Things.

24. Weart, E., The Story of Your Blood.

25. Wilson, M., The Human Body: What It is and How It Works.

Inexpensive Materials

About Your Blood, John Hancock Mutual Life Insurance Co., Public Relations Dept., 200 Berkeley St., Boston 17, Mass.

Care and Feeding of Laboratory Animals, Ralston Purina Co., Nutrition Service, St. Louis 2, Mo.

The Challenge of Health Research, in "Health Heroes Series," Metropolitan Life Insurance Co., School Service Department, 1 Madison Ave., New York 16, N. Y.

Food Facts; How to Conduct a Rat Feeding Experiment,Wheat Flour Institute, 309 W. Jackson Blvd., Chicago 6, Ill.

Free and Low-Cost Materials for Science Clubs of America; Thousands of Science Projects, Science Service, 1719 N. Street, N. W., Washington 6, D. C.

The Story of Blood, American National Red Cross, Washington 6, D. C.

Your Heart and How It Works, (chart and pamphlets), American Heart Association Inc., 44 East 23rd St., New York 10, N. Y.

U. S. Gov't. Printing Office, Nutrition Charts, (set of 10 charts in color, 19 x 24 in.) Washington, D. C., 75¢ per set.

"How to Make Skeletons" (Turtox Service) #9, General Biological Supply House, (Turtox), 8200 S. Hoyne Ave., Chicago, Ill. 60620.

A COMPARISON OF THE SKELETAL AND MUSCULAR SYSTEMS OF VERTEBRATE ANIMALS AND INSECTS

Introductory Material

Many multicellular organisms are without skeletons. Some protists, such as the

Introductory Material (continued)

radiolarians, secrete hardened coverings outside the cell membrane, while other species have hard, rodlike bodies within the cell that lend form and support. None of the larger animals could have developed to their present sizes without supporting skeletons. They would collapse without an outer exoskeleton, as in arthripods and some mollusks, or an endoskeleton, as in invertebrate animals such as sponges and starfish.

Skeletons not only prevent animals from collapsing, they also provide protection for the soft, vital parts. In addition, the skeletal and muscular systems respond to nervous and endocrine systems to bring about locomotion or movement.

Suggested Activities

1. Comparison of the skeletal and muscular systems of vertebrates with those of insects, crayfish or lobsters

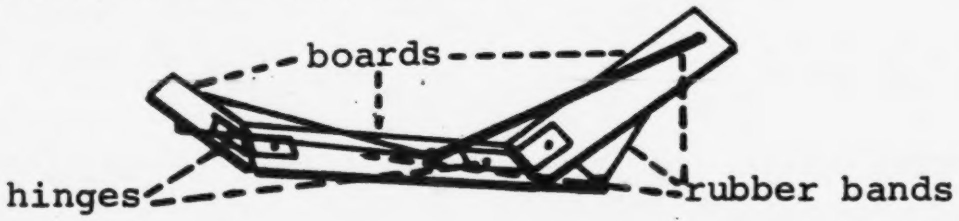
   Using actual specimens of the larger legs of the grasshopper, crayfish or lobster, locate the principal muscles and have the students find where they are attached to the exoskeleton. What are some advantages of an exoskeleton? What are some of the disadvantages? What happens when an insect or a crayfish outgrows its exoskeleton? (If actual specimens are not available, use charts and drawings instead).

   Using the leg of a frog, make a similar study. What are the advantages and disadvantages of an endoskeleton?

   Obtain a long bone and an attached joint from a butcher shop or the meat department of a supermarket. Examine the bones for ligaments and cartilage. Have one long bone sawed lengthwise. Have students locate and observe the periosteum, the compact bone, the spongy bone and the red and yellow marrow. What functions do vertebrate bones have in addition to support and movement?

2. Constructing Models of Exoskeletons and Endoskeletons

   Ask members of the class to build a model of a human arm or leg, using pieces of wood to represent bones and heavy rubber bands to represent muscles. Join the pieces of wood at the joints with small metal hinges, strips of leather or other flexible material. Attach the rubber bands to the wood at appropriate places with tightly tied cord or tacks.



   When models have been completed, have members of the class show how skeletal muscles work in groups that oppose each other.

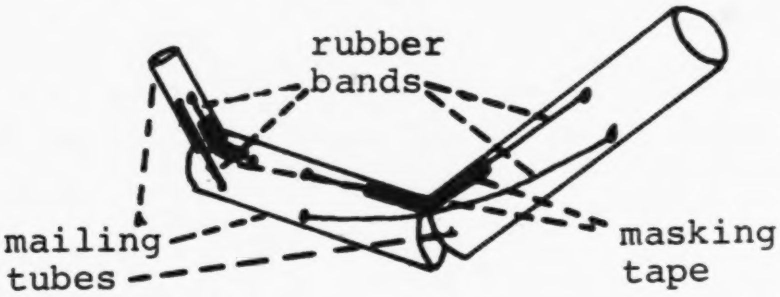
   If a well constructed puppet is available, examine the joints of the arms and legs to see how they are constructed to simulate natural movements. Why is it necessary to attach the rubber bands at specific places and not at others to permit proper movement? In your model, what corresponds to ligaments, to tendons?

Suggested Activities (continued)

What difference would it make if these structures were replaced with muscles? What actually happens when a joint is sprained or dislocated?

Call attention to the difference in thickness when a rubber band stretched or drawn up. Have the students feel their own upper arm while the arm is extended and when it is drawn up. Is the biceps thicker when the arm is drawn up or when it is extended? Do muscles work by pulling or by pushing? How does the tongue (an organ composed of several muscles) push an unwanted object out of the mouth? An earthworm moves but has no skeleton. Observe an earthworm. Notice the difference in thickness of the earthworm when it is extended and when it is contracted.

Next, have the students use small, paper mailing tubes instead of wood to represent parts of the exoskeleton of an insect or crustacean. Pass the rubber bands inside the tubes and attach them to the tubes, imitating as nearly as possible the manner of attachment observed for real exoskeletons and muscles. Hinges can be made of any convenient pliable material that will attach to the paper tubes. Masking tape will work very well, but it should be attached at one side only to allow free movement.



Mention some of the largest animals that possess exoskeletons. How do these compare in size with the largest animals that have endoskeletons? Can you suggest why all of the larger animals have one type of skeleton and not the other?

3. A Comparison of Motions of the Human Body with Various Mechanical Devices

Have students study a human skeleton or model or chart thereof and locate and identify hinge joints, ball-and-socket joints, gliding-type joints.

Ask members of the class to demonstrate different motions of the arms, legs, head and trunk of the human body. After each motion, have the rest of the class compare the motion with a mechanical counterpart. For example, some mechanical devices that have their counterparts in the human body are a ball-and-socket mounting of a camera tripod, a door hinge, a pivot-and-hinge joint of a fountain pen set.

4. A comparison of Skeletons of Different Vertebrates

Have the students study mounted skeletons (or charts) of several different vertebrates. Have them draw the fore leg, arm or wing of selected species showing the first bone (humerus) in one color in each case and the radius and ulna each in two other colors.

Suggested Activities (continued)

5. A Study of Tendons and Ligaments

Obtain enough fresh discarded chicken feet from the butcher or supermarket so that each student or team may have one for study. Have them learn to distinguish between tendons and ligaments. Why not have muscles function in the place of these two structures? Chickens and other birds are often seen walking in snow without apparent discomfort. Explain.

6. A Study of X-ray Photographs of Broken Bones and Dislocations

If possible, obtain a few X-ray photographs of broken bones and dislocations from a doctor or hospital. Hold the pictures against the window or other sources of illumination and distinguish between simple and compound fractures. Distinguish between fractures and dislocations.

7. Kinds of Muscles

Have the students examine prepared miscroscope slides of the three main types of muscles: smooth, striped (striated) and heart muscles. Why are the striped muscles usually called skeletal muscles. What are the functions of the other muscle types?

8. Comparison of the Rate of Heartbeat

Demonstrate the beating of the heart of a frog or of Daphnia. Have the students compare the rate of the heartbeat of the frog or Daphnia with their own. Compare these with the rate of heartbeat of a student after light exercise. Discuss the difference between voluntary and involuntary muscles. Point out that muscles contract in response to nervous stimulation.

Emerging Concepts

1. The skeletal and muscular systems give the body size, shape and posture.
2. The skeleton functions in supporting other parts of the body, in locomotion or movement and in protecting vital body parts.
3. Two kinds of skeletal systems are found in animals and some protists: endoskeletons and exoskeletons.
4. Vertebrates, including man, have highly developed endoskeletons (internal skeletons).
5. Some muscles, such as those of the earthworm and those of the disgestive tract of higher animals, may produce movement without being attached to bones. Most movement of animals, especially locomotion, is the result of muscles and bones working together.
6. Arthropods and vertebrates have appendicular skeletons that act as levers. Muscles supply the force and the joints act as fulcrums.

Equipment

Fresh or preserved grasshoppers, crayfish, crabs or lobsters. Fresh or preserved

Equipment (continued)

frogs or small mammals such as mice. Long bones with an included joint from the meat market or supermarket. Mounted skeletons of vertebrates. Charts and drawings of muscular and skeletal systems. Disseting instruments. An assortment of small boards approximately ½" x 4" to 8". Sections of mailing tubes of about the same length as the boards, rubber bands, masking tape or hinges

Other Aids

Human skeleton, model of human skeleton or charts. Skeletons or charts of skeletons of several different vertebrates.

Films

1. The Human Skeleton, j-s, 11 min., 370
2. The Skeleton, j-s, 12 min., 669
3. The Human Body: Skeleton, j-s-c, 10 min., 1678
4. Muscles and Bones of the Body, j-s, Coronet Instructional Films
5. The Human Body: Muscular System, j-s, 14 min., 4291
6. The Muscular System, j-s, 11 min., 373

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15. Wilson, M., The Human Body: What It Is and How It Works.

COORDINATION AND CONTROL THROUGH THE NERVOUS SYSTEM AND THE ENDOCRINE SYSTEM

Introductory Material

Highly specialized cells of the nervous system carry out three main functions: detection, communication and coordination and control. Responsibility for the last two functions is shared with the endocrine system. Through the sense organs, previously studied, higher animals including man become aware of such stimuli as light, sound, heat, cold, odors and pressure. Impulses from the sense organs are carried by nerves to the brain, and the brain sends back impulses through the nerves to appropriate parts of the body which respond in action.

Since most of the sense organs have been studied earlier, the main emphasis of this section will be on coordination and control.

The plan is to engage the students in three experiments, one involving simple reflex response, a second involving conditioned reflex, and a third involving continued purposeful learning. Data must be recorded on the activities because the data will serve as a means of relating structure to function. Experiments with peers and lower animals, and text, charts, and models need to be utilized fully by the student. Following the activity, the teacher should get across the idea that in order for the student to understand what he did and why he did it, he needs to learn something about the structure and organization of the nervous system. This study should take several days.

Many junior high texts almost completely leave out this system. A few cover the subject in detail. A brief outline of information will be included as ideas and concepts.

Suggested Activities

1. The Nervous System

   Simple Refliexes: Have students form pairs. Each will test the knee jerk reflex of the other by hitting the knee-cap with the side of his hand. The legs should be crossed with one leg swinging freely. The following information should be recorded in the data book: (1) Procedure, (2) Results, and (3) Answer to the questions "Did you think about jerking your knee?" Did you have any control over the jerk?" The teacher should explain this response or result as a simple reflex action. Students should think of other examples. Later, after the organization of the nervous system is learned, the reflex arc will be explained. Concepts 1 and 4

   Learned Behavior - Conditioned Reflex: Set up a situation for performing an experiment to illustrate this. Have students get out a pencil and sheet of paper. As directions (the stimulus) are given to draw a line or make a dot, a bell should be rung. Repeat this a number of times; then simply ring the bell. Have students record the procedure and results. Concepts 2 and 4. This activity represents a level of response higher than that of the simple reflex, because some "learning" is involved. Ask students for other illustrations of conditioned reflex and have them keep looking for other examples all during the study. Concept 2

Suggested Activities (continued)

Purposeful Learning: Distribute to each student a copy of the following paragraph or something similar, with the instructions to read it carefully several times:

"The brain is located within a bony case, the caranium. Three membranes, called meninges (me nin ges) as well as bone, protect it. Between the meninges is fluid, which serves as a shock absorber."

After several minutes take up the sheets and distribute a second one with the following paragraph mimeographed on it. Instruct the students to read the paragraph carefully.

"People would be in an awful fix without a spinal cord! Through it impulses travel from sensory cells to the brain. The brain then sends messages through it to muscles or glands, resulting in a response to the stimulus. The spinal cord is very important! It is carefully protected just like the brain." After several minutes, take up the sheet. Than ask the students to list in their data book two structures that protect the spinal cord. If this is done correctly, ask how the student happened to know the answer. The teacher should lead the class in seeing that two instances of purposeful learning were involved in this experiment. By learning the information on each sheet, an association was made when the question was asked. Therefore, the question was answered intelligently. This represents a third level and a higher level of learning. Concepts 3 and 4

Analysis of data: The teacher should refer to the above activities, asking the students to analyze the situations to see what actually took place. This should lead to the following facts: A stimulus was received by sensory cells in the knee. The result was the knee jerk. This is called a response. The stimulus in the second situation was received by the ear. An interpretation of the stimulus resulted in the writing of the line, etc. This was the response. The eye perceived the written words. The ear perceived the instructions. The response resulted from the interpretation of these stimuli. With this bit of analysis, the teacher can then direct the thoughts of the students to a consideration of the sensory cells and organs that receive and/or perceive stimuli and to the organization of the nervous system. Concept 4

The Sense Organs

Perform experiments to show the distribution of heat, cold, pressure and pain receptors. Reference 8, pp. 320-22.Concept 5

Test for the location of sour, bitter, salt and sweet receptors on the tongue. Reference 8, pp. 320-22.Concept 6

Use models to study the structures and functions of the parts of the eye and ear. Concept 6

Examine the frog to compare the amphibian eye and ear to the human eye and ear. Concept 6

Look at the structure of the grasshopper's compound eye and "abdominal" ear. Concept 6

Suggested Activities (continued)

Organization of the Nervous System

Use models, charts, textbook, films, specimens of different animal brains. Concepts 7, 8, 9, 10 and 11

The Nervous System in Action

Refer to activity Simple Reflexes. Explain, show, illustrate the simple reflex arc. The sensory cell is stimulated. An impulse which is an electrochemical reaction is set in motion. The impulse travels through the sensory neuron to the spinal cord in which it almost comes into contact with the dendrites of a motor neuron. This area of near contact is referred to as a synapse. (Point out an illustration). The impulse has to bridge the synapse. The terminal ends of the axons produce a chemical substance, acetylcholine. This substance stimulates the dendrites of the next neuron, resulting in the passage of the impulse through the neuron. Would it be possible for an impulse to travel in two directions? (The answer is "no.") Impulses travel in only one direction through a neuron, from dendrites to nerve cell body, to axon. Involved in this reflex arc are: (1) a sensory or receptor neuron, (2) a motor or effector neuron and (3) the muscles which are innervated by the motor nerves.

Refer to activity Learned Behavior. Ask students to suggest ways in which this activity differed from the above. Some ways should be: (1) the sensory cells were located in the ear; (2) the stimulus was due to sound waves; (3) more than simple reflex arc was involved. Some learning resulted which implies the involvement of the brain as well as the spinal cord. Follow this by tracing the route of the impulse, from inner ear to auditory nerve, to the auditory center in the brain, across a synapase to an association neuron which interprets the impulse, across a second synapse to an effector neuron, through the axons or nerves down the spinal cord out through a spinal nerve which has fibers that innervate the muscles involved in the writing process.

The question should then be asked, "Why did some of you write when you were not told to do so?" This should lead to the idea that a nerve pathway was established by repetition of the stimulus plus the sound of the bell. The sound acted as a substitute stimulus resulting in a reflex action. Some learning occurred, however, after repetition. The same response resulted without the involvement of the brain.

Conditioned reflexes are very important in every day living. Recall some already mentioned and try to recognize some others. Many experiments have been done with animals to condition them. Some of the students might be interested in setting up one of them.

Refer to activity Purposeful Learning. Begin by asking, "What stimulus was involved?" "What sensory cells were stimulated?" "Was the brain involved in this activity?" "Did you learn something new to you from paragraph 1? from paragraph 2?" "Did you answer the question correctly?" "Was the question answered directly in paragraph 2?" "How, then, did you answer it correctly?"

This inquiry should reemphasize concept 3. Follow the pathway of the impulse from ear and eye to the right areas of the brain, then point out on the board that the impulse would have to go from sensory neurons to association neurons to the motor nerves, which would result in writing or speaking the answer. In summarizing this section, concept 4 can be reemphasized. (The nervous system helps you to

Suggested Activities (continued)

adjust to your environment.) This can be used to bridge the gap to the endocrine system.

2. The Endocrine System--The System of Internal Balance

The study moves from the nervous system, that for external regulation, to the endocrine system, that for internal regulation or control. The student is to learn that his body is "regulated" and "controlled" internally by the secretion of hormones by a system of ductless glands. Some of these hormones are responsible for the physical changes the student experiences at this particular age.

Set up a demonstration experiment on the effects of hormones (thyroxin) on developing tadpoles. Capable students can be delegated this responsibility with only a little supervision. This activity can be used to stimulate interest and as an excellent teaching tool. Reference 8

Make an outline drawing of a human body on the chalk board or on a large piece of wrapping paper. Have prepared in advance cut-outs of the different glands, using different colors of construction paper. Prepare flash cards on which pertinent information is written about each of the endocrine glands. The color of the flash card may or may not match the color of the gland it refers to. Have students practice matching characteristics with appropriate glands.

For example:

NAME:
Thyroid

SECRETION:
Thyroxin

REGULATES:
Metabolism

OVERACTIVITY results in:
bulging eyes, nervousness,
underweight

UNDERACTIVITY results in:
goitre, sluggishness,
overweight

Note: An overhead projector with colored overlays can be used to accomplish the same results as the method outlined above.

Disassemble a human manikin or torso for discovering the locations of each gland. Concepts 12, 13, 14 and 15

Students could be given a ditto sheet with an outline drawing of the human body. As each gland is discussed he can draw the gland in and write the pertinent information in the margin. Concepts 12, 13, 14 and 15

Emerging Concepts

1. Some of our responses are automatic and are made without any thought. This is called simple reflex.

2. Repetition of an experience establishes nerve pathways. A substitute stimulus (the sound of a bell) can replace a primary stimulus (the spoken directions) in initiating an impulse. The resulting response becomes automatic. This constitutes a conditioned response or behavior.

3. With the establishment of nerve pathways, learning is increased. More learning makes possible a greater ability to associate knowledge and to reason.

4. In the body there are various kinds of sensory cells that receive stimuli which make one aware of his environment. Through various kinds of stimuli the responses to stimuli help one to adjust to his surroundings.

5. Special sensory cells are distributed over the body to receive stimuli such as heat, cold, pressure, pain and touch.

6. Organs of the body, such as the ear, eye, tongue, and nose, are specialized in structure and function to receive such stimuli as sound, light, taste and smell.

7. The neuron is the unit of structure and function of the nervous system. The neuron consists of an axon, dendrites and a nerve cell body.

8. The three types of neurons are: sensory (acceptors) which receive stimuli; motor (effector) which bring about a response and association which direct impulses from sensory neurons to the appropriate motor neurons.

9. Nerves consist of bundles of nerve processes (axons and dendrites).

10. A ganglion is a group of nerve cell bodies.

11. The nervous system consists of a central nervous system, a peripheral nervous system and an autonomic nervous system. The central nervous system is composed of the brain and spinal cord. The peripheral system consists of the cranial and spinal nerves. The autonomic system consists of the sympathetic and parasympathetic nerves.

12. The endocrine system is composed of a number of ductless glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, testes) which bring about the internal balance and control.

13. Ductless glands secrete hormones directly into the bloodstream.

14. Hormones function in regulating control of various body structures.

15. Malfunctioning glands produce abnormal characteristics.

Equipment

bell, wrapping paper, construction paper

Films

1. Speech Chain, Bell Telephone Film

Films (continued)

2. Ears and Hearing, j-s, 9 min., 425

3. Eyes: Their Structure and Care, j-s, 11 min., 1899

4. Sense Perception, part 1, The Wonder of the Senses j-s, 27 min., 7013

5. Animal Behavior j-s, 10 min., 1526

6. Nervous System e-j, 11 min., 268

7. Human Brain, e-j-s, 11 min., 867

8. Endocrine Glands, j-s, 10 min., 242

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2. Brandwein, et al, Life, Its Forms and Changes.

3. Frasier, Smith, The Biological Sciences.

4. Groch, You and Your Brain.

5. Pfeiffer, The Human Brain.

6. Miller, The Adventure Book of the Human Mind.

7. Reidman, Our Hormones and How They Work.

8. Morholt, E., et al, A Sourcebook for Biological Sciences.

UNIT IV. HOW LIFE CONTINUES FROM GENERATION TO GENERATION: HEREDITY, GROWTH AND REPRODUCTION

Introducing the Unit

There are various ways of introducing a unit having to do with heredity, growth and reproduction. In this study the pupil may be led into a personal relationship with science so that he may realize that he and all other organisms are products of their environment and heredity.

The teacher might try introducing the unit by having students list on the chalkboard various human characteristics. After a list of ten or more characteristics has been completed, ask which are inherited and which are the results of the environment. Some characteristics may be the result of both. If there is lack of agreement, have the students do additional reading and report back.

Whether or not the ensuing discussion remains on a general basis or moves to a personal basis will depend on the teacher and the composition of the class. Obviously no student should be embarrassed or ridiculed by any of his classmates because of physical characteristics or other qualities. Children from broken homes or from different racial, national or religious backgrounds may be reluctant to participate. The point to be developed, in any case, is that inheritance is the result of physical or chemical determiners (genes) that are passed on from generation to generation. A family portrait taken from the newspaper or other source showing three or four generations can be used to emphasize that certain characteristics are inherited.

The scope and sequence of materials selected for this unit should be influenced by the community and the interests, aspirations and growth characteristics of the young people at grade seven in your classes. For example, several texts for the seventh grade include genetic coding and DNA structure. You may decide that these concepts are beyond many of your pupils and that time will be better spent dealing with heredity and reproduction on a less sophisticated level.

Before attempting the exercises described below, prepare some microscope demonstrations of cells in various stages of division. Discuss the importance of chromosomes and the necessity that they be distributed evenly and exactly to newly formed cells.

HOW LIFE CONTINUES AMONG THE PROTISTS

Introductory Material

Use microscope demonstrations of slides to demonstrate that such protists as paramecium have nuclei in which chromosomes are always present, though not always clearly visible under the microscope. Mention that some protists (bacteria and blue-green algae) have genetic material (DNA) which is not organized as nuclei.

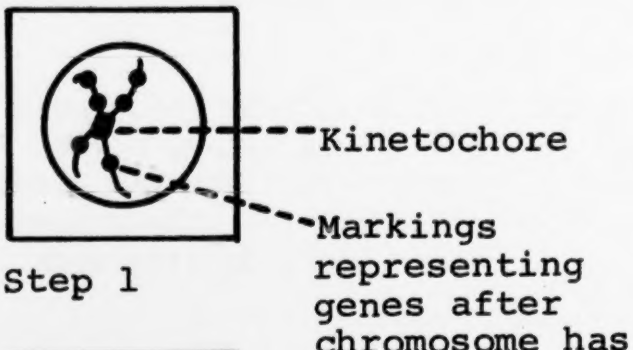
Suggested Activities

1. Chromosome and Gene Relationships

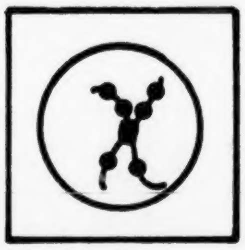
Parts of the cell studied in Unit III included the cell membrane, cytoplasm and nucleus. Other parts must now be introduced. Have the students take a large sheet of paper and draw a large circle on it to represent the nucleus of the cell and a still larger circle around this to represent the cell membrane. Use pipe cleaners to represent the several chromosomes. One pipe cleaner may now be placed by each student within the nucleus of cell to represent a chromosome. This pipe cleaner should be marked with three marking pens of variable color along its length. Also along the length of the chromosome is a structure called the kinetochore. These markings represent individual genes which are composed of a substance called DNA (deoxyribonucleic acid) which has the unique power of replicating itself through a series of complex steps.

2. Mitosis

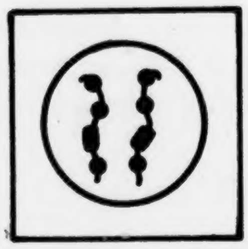
Before a cell divides, the chromosomes replicate. Each student may take the pipe cleaner used in part one and twist another similar pipe cleaner around it to illustrate the replication process (step 1). Following replication the chromosome moves toward the center of the cell (step 2), followed by separation (step 3). Each chromosome then moves to opposite ends of the nucleus (step 4), separation of the nucleus has occurred and two new daughter nuclei are formed (step 5). This series of complex steps by which nuclear material is duplicated and separated is called mitosis. Following mitosis a division of the cytoplasm occurs and two new cells are formed (step 6).



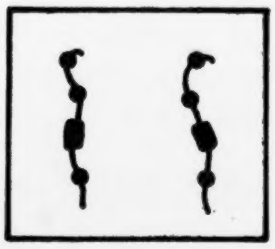
Step 1



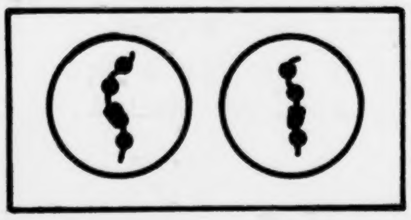
Step 2



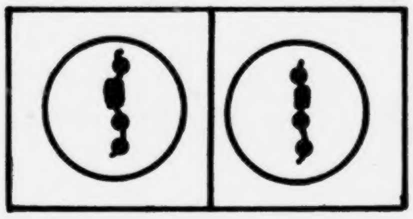
Step 3



Step 4



Step 5



Step 6

Suggested Activities (continued)

3. Cell Division in Protozoa

   Tetrahymena, a ciliated protist or protozoan, reproduces by one cell dividing to produce two offspring cells, the parent disappearing in the process. This process is called fission. Fission may or may not involve mitosis. In the ciliates it does not.

   Tetrahymena is easily cultured and is clearly visible under the low power of the microscope. It is readily obtainable from biological supply houses.

   Have students observe the various stages of division in Tetrahymena. For addiional exercises with Tetrahymena see reference 13.

4. Fission in Bacteria

   Further activity might involve the students' preparing agar slants of bacteria and observing growth. It would be interesting for the student to calculate the number of bacteria that would be produced in a period of time. (Most bacterial cells divide at 20 minute intervals).

5. Conjugation in Paramecia

   This is simply the temporary fusion of two cells or organisms which superficially are alike. Paramecia make contact in the area of the gullet and nuclear material passes from one to the other. It has been discovered that following their separation each of the cells are rejuvenated and are able to reproduce by fission. Reference 13, p. 424.

   To illustrate the conjugation process, a flannel board may be used to show the coming together, fusion, exchange of nuclear material and separation of paramecia cells followed by fission. Film number four.

Emerging Concepts

1. Continuity in the protists is the result of one cell or individual dividing to form two, the original cell disappearing in the process. This type of division is called fission. Fission in the protists may occur without mitosis (ciliates, blue-green algae and bacteria) or it may be accompanied by mitosis.

2. Mitosis is the division of the nucleus, in which the chromosomes are duplicated and separated into two identical daughter nuclei.

3. Conjugation, as it occurs in the protists, is a fusion of cells which appear to be much alike. When fused there is an exchange of nuclear material of the two cells. This process results in the rejuvenation of the two cells, which then continue to reproduce by fission. Conjugation is considered to be among the most primitive types of sexual reproduction in which two sources of genetic material (DNA) are exchanged and recombined.

4. Conjugation and fission provide continuity of life from generation to generation among the protists by duplicating and passing on genetic material (genes) that are usually arranged in chromosomes. The genetic material is known to be DNA (deoxyribonucleic acid), a complex chemical compound.

Equipment

Pipe cleaners, paper, agar media, and culture of Tetrahymena

Films

1. The Thread of Life , 59 min., Bell Telephone Co., 1960, Free loan
2. A Frog's Life, Coronet Instructional Films, Chicago, Ill., e-j , 10 min., 1942
3. Single-celled Animals,—Protozoa, Encyclopedia Britannica Films, Inc., Atlanta, 17 min., 5374
4. Wonder of Reproduction, Moody Institute of Science, Los Angeles, Calif., e-j, 12 min., 4893

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4. Beadle, George and Muriel, The Language of Life.
5. Beeler, N. F., Experiments with a Microscope.
6. Bonner, D. and S. Mills, Heredity, 2nd Ed.
7. Brandwein, P., R. Burnett, and Robert Stollberg, Life, Its Forms and Changes.
8. Cosgrove, M., Wonders Under a Microscope.
9. Cosgrove, M., Strange Worlds Under a Microscope.
10. Crick, Francis H. C., The Structure of Hereditary Material.
11. Frazier, R. and H. Smith, The Biological Sciences.
12. Levine, R., Genetics.
13. Morholt, E., et al, A Sourcebook for the Biological Sciences.
14. Moore, R., The Coil of Life.
15. Watson, J., Molecular Biology of the Gene.

HOW LIFE CONTINUES AMONG ANIMALS

Introductory Material

The seventh grade level is an appropriate stage in development to further acquaint students with the biological role of sex within the broad perspective of biology generally. At this age boys and girls are becoming more sex conscious and their interest in the opposite sex is emerging. Within the broad framework of biological concepts their natural curiosities can be satisfied and a wholesome attitude toward the processes of reproduction can be cultivated.

Suggested Activities

1. Asexual Reproduction

   Prepare microscope slides from the culture of living budding hydra. References 2 and 3. Have the students observe and sketch in their data books what they see. Allow time for them to discover that the buds are new individuals produced from a single individual. This process is called budding. Concepts 1 and 2.

   Some spring water or chlorine-free tap water should be on hand when planaria arrive. Pour the planaria from the shipping jar into a dish such as a finger bowl, petri dish or cereal bowl. Place a drop of water from the bowl on a glass microscope slide and transfer a planarian to the slide, using a cotton swab. Chill the slide on an ice cube to slow down the movements of the planarian. After the planarian has relaxed, cut the worm with a sharp razor blade into two pieces. Place each half in separate dishes, cover with spring water, cover the dish to prevent evaporation, and place in a cool, dark place.

   Examine the pieces every two days for about 12 days. Record each observation by a sketch in the data book. To assure success, several worms should be cut. Each piece is capable of producing a complete worm. Again allow the students to discover that only one individual is involved in the production of new individuals. This process is called regeneration. Concepts 1, 3, 21, 22, and 23.

2. Sexual Reproduction

   Meiosis: Material on meiosis is given in each Life Science text on the state list. The purpose is simply to introduce the term meiosis. Concepts 4, 5, 6, and 7.

   Fertilization: This concept must also be taught by the teacher with the use of reference books and textbooks. Concepts 8, 9, 21, 22 and 23.

3. Metamorphosis in insects

   No doubt you have specimens of wingless grasshoppers (nymphs), adult grasshoppers, caterpillars (larvae) of butterflies and moths, cocoon (pupae) of butterflies and moths, and adult butterflies and moths collected during the fall. Display the specimens and allow sufficent time for the students to discover the different stages in the development of the grasshopper, moth and butterfly.

Suggested Activities (continued)

Films 7, 10 and 12. Concepts 10, 12, 21, 22 and 23

Breeding and Raising Fruit Flies: Activity 19 in reference 24. Concepts 11, 12, 21, 22 and 23

Observing an Ant Colony: Activity 20 in reference 24. Concepts 11, 12, 21, 22 and 23

4. Metamorphosis in Frog and Toad

During the spring frog and toad eggs can be collected from almost any pond or lake in Georgia. Frog eggs will be found in jelly-like clusters, while toad eggs occur in strings. Place the eggs in large aquarium jars filled with water. The eggs will hatch soon if the temperature of the water is maintained at about 60 degrees to 65 degrees F. Activity 16, reference 24. Reference 23, p. 463

Display the frog and/or toad eggs in aquarium jars. Have students describe and discuss the possible function of the jelly-like material. Record in data book. (The jelly-like material helps to keep the eggs stuck together and to keep them afloat.)

External fertilization occurs and development of the fertilized egg (zygote) begins. Concepts 15, 16, 21, 22 and 23

Place small masses of eggs in small bowls and examine them using a hand lens or stereo-microscope and record observations. (The dark spot on the top of the egg is fertile. The yellow area just under the dark spot is the yolk sac containing food for the developing embryo. The yolk sac is attached to the belly of the tadpole. Normally the eggs will hatch in eight days or so. Concepts 15, 21, 22 and 23

When the eggs hatch, observe the young tadpole and sketch in data book. Repeat this every few days, discussing the changes that have occurred. When the adult frog or toad emerges, examine carefully, sketch, and label parts observed. Place the frog or toad in a terrarium and have students care for them. Concepts 13, 14, 21, 22 and 23

Film 4. Concepts 13 and 14

5. Sexual Reproduction in Birds:
Hatching Chick Eggs

Construct an incubator and adjust the size of the light bulb so that a temperature between 101 degrees F. and 103 degrees F. can be maintained. References 23 and 24

Obtain about one dozen fertile eggs from a hatchery. Find out how old the eggs are. They should hatch in about 21 days after being laid. Arrange for a hatchery or local farmer to take the chicks after hatching. Do not allow the children to take them home unless you are sure they can take care of them.

Suggested Activities (continued)

Display the chick eggs and ask how these differ from frog eggs. (Fertilization is internal, the egg is covered with a shell as it passes down the oviduct). Mark the eggs with (X) on one side so that they can be turned daily. Why is this necessary? (This is necessary to keep the developing chick embryo from sticking to the shell). Point out the temperature range and its importance. Why is the pan of water necessary? (It is necessary to adjust the humidity to about 60 percent to avoid loss of moisture). Open an egg after 2 days, 4 days, 7 days, 9 days and 19 days of incubation. The above references will give specific directions to follow in opening an egg. Observe and sketch each embryo. Concepts 17, 18, 19, 20, 21, 22 and 23.

6. Sexual Reproduction in Mammals

There are no activities suggested in this section unless you can find a film on reproduction in mammals. Do not use the film on Human Reproduction. Preview any film carefully and make a decision as to its use in your individual situation. Life Science textbooks have some information on this topic. However, students should be told that fertilization is internal and the developing embryo is nourished by a placenta, a specialized tissue which develops after fertilization in the body of the female. The period of internal development, pregnancy, varies with the species. The young are born alive and are fed by mammary glands. Concepts 21, 22 and 23

Emerging Concepts

1. Regeneration and budding are asexual methods of reproduction in which new individuals are produced from a single individual.

2. When a new individual arises as a bud growing out from a particular part of an adult, the process is called budding.

3. Regeneration is the replacement of missing parts by the growth of new tissue.

4. Mitosis results in the production of two identical daughter cells.

5. Growth is due to mitosis, increasing the number of cells and the enlargement of cells accomplished by the diffusion of nutrients through the cell membrane from the cell environment.

6. Each species has a characteristic number of chromosomes in the nucleus of body cells, for example 32 in hydra, 72 in the chick and 46 in man.

7. Meiosis results in the production of gametes with one half the number of chromosomes in body cells.

8. Fertilization is the fusion of sperm and egg nuclei forming the fertilized egg, the zygote.

9. The essential feature of sexual reproduction is the fusion of the nuclei of two separate cells to form offspring.

10. Some insects, such as the grasshopper, go through three stages during development: egg, nymph and adult. This process is called incomplete metamorphosis.

Emerging Concepts (continued)

11. Other insects, such as the butterfly, moth, fruit fly and ant, undergo marked changes in appearance during development. There are four distinct stages: egg, larva, pupa and adult. This process is called complete metamorphosis.

12. Insects reproduce sexually.

13. The process by which a tadpole develops into an adult frog or toad is called metamorphosis.

14. Metamorphosis occurs in all amphibians.

15. Amphibians carry on sexual reproduction.

16. Fertilization occurs externally in fish and frogs.

17. Reproduction of birds (chick) is sexual.

18. Fertilization occurs inside the female bird.

19. Birds do not pass through a metamorphosis since the young birds look like their parents.

20. Under suitable environmental conditions of temperature and moisture, young birds will hatch from fertilized eggs.

21. All life comes from pre-existing life by cell division and by the union of specialized cells called gametes.

22. Life continues generation after generation by asexual and sexual reproduction. Asexual reproduction usually maintains exactly the same type, whereas sexual reproduction recombines characteristics to produce individuals that are different.

23. In the details of the reproductive process there is much diversity among living organisms.

Equipment

Incubator, chicken eggs (fertile), budding hydra, planaria, frog and toad eggs, finger bowl, petri dishes, cotton swabs, razor blades, specimens of wingless grasshoppers, caterpillars, cacoons of butterflies and adult butterflies, ripe banana, jars, funnel, magnifying glass, stereomicroscope, 2 pieces of 3/4 by 3/4 inch strip of wood 11¼ inches long and two pieces 6 inches long, nails, waterproof adhesive tape, 2 pieces of glass 12 by 16 inches, soil, and pan approximately 14 inches by 18 inches.

Films

1. Amphibians, e - j - s, 11 min., 1906
2. Amphibians, e - j, 11 min., 1266
3. Frog, j - s, 11 min., 220
4. Frog's Life, e - j, 10 min., 1942
5. Ants, e - j - s, 10 min., 409
6. Cecropia Moth, j - s, 10 min., 1185
7. Sponges and Coelenterates: Porous and Sac-Like Animals, j - s, 10 min., 1702
8. Asexual Reproduction, 10 min., 1187
9. The Chick Embryo from Primitive Streak to Hatching, s, 13 min., 5366
10. Heredity, (set of 9 films), 30 min. each: Fact or Fallacy, Many Pairs of Genes, Sexuality and Variation, The Sex Chromosomes, It Runs in the Family, Heredity and Chromosomes, Reproduction and Heredity, Heredity and Environment, and Mendel's Experiments, Indiana University
11. Perpetuation of Life, 29 min., Indiana University

Slides

1. Chicks (set of 12 transparencies), Carolina Biological Supply Co., Burlington, N.C.
2. Frog Eggs (set of 16 transparencies), Carolina Biological Supply Co.
3. Hydra Development (set of 20 transparencies), Carolina Biological Supply Co.

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21. Van Overbeek, J., The Lore of Living Plants.

22. Miller, D. and G. Blaydes, Methods and Materials for Teaching the Biological Sciences.

23. Morholt, E., and A. Joseph, A Sourcebook for the Biological Sciences.

24. Wailes, J., Living Things, Vol. I

25. Zeichner, I., How Life Goes On.

REPRODUCTION AMONG PLANTS

Introductory Material

The overall plan is to allow the pupils to become acquainted with the great diversity in reproduction in the plant kingdom. Specimens of representative plants should be arranged as demonstrations at several stations throughout the room. The teacher may raise appropriate questions about each demonstration, or questions phrased to emphasize important features of each method of reproduction may be included on a poster or printed sheet accompanying each demonstration. Students will then be called upon to set up demonstrations that illustrate additional types of reproduction in plants.

Suggested Activities

1. Reproduction in Representative Types of Plants

With student help, set up displays of the following: algae, fungi (as molds with spores, mushrooms), mosses (with sporophytes), ferns (with sori and sporangia), beans, corn, potatoes with eyes, African violets, Byrophyllum with buds on the leaves, coleus plants, a package of yeast, plants in flower, and other appropriate specimens. Pictures may be substituted for unavailable types of plant reproduction.

Open the discussion by asking such questions as: How does a farmer go about planting a potato patch? Has your mother ever tried to root African violets? What did she do? What is the yellow powder in this flower? What happens when one plants a bean or a kernel of corn? What are pine cones for? What are these black balls on the mold?

List on the board and in data books as many methods of plant reproduction illustrated by the specimens and any others they can add. This is important. It will be used in organizing information later. Concepts 1 and 2

2. Reproducing Plants

Assign students (individual, pairs or groups) a responsibility for performing one of the following and any other activities the teacher may suggest.

Plant potato eyes (vegetative reproduction--propagation).

Plant corn kernels and bean seeds. If the seeds can be planted next to a glass, the sprouting process can be observed better (Reproduction by seeds--sexual).

Suspend the petioles of African violet leaves in water (vegetative reproduction).

Sprinkle mold spores on a piece of bread taken from an unopened package of bread (reproduction by spores).

Place a small sweet potato in water (vegetative).

Observe algae very carefully for several days. (Use microscope). (Reproduction by fission).

Make a yeast culture; mix about 1 tsp. dry cooking yeast in 250 ml. water. Add 1 tsp. sugar. Observe for several days. Examine a slide microscopically. (Reproduction by budding).

Place a little pollen in a drop of 10% sugar solution in a depression slide. Observe at intervals during the class period (Pollen tube should grow).

Sprinkle moss or fern spores on the top and sides of a moist flower pot. Place the inverted pot in a dish of water. Cover with a bell jar. (Reproduction by spores). Reference 17, pp. 374, 645

Suggested Activities (continued)

The class needs to be aware of what all are doing. As they observe they should share results with the class. Record all data. While the experiments are in progress, time should be taken to organize the information brought out in the opening period of inquiry.

Students have learned "asexual" and "sexual" methods of reproduction. List under each of these headings the examples that are listed on the board and in their data books.

If some students have not already asked about sporophytes on the moss, ask them about it. Explain alternation of generations as simply as possible in the mosses and ferns. Reference 17, p. 374. Film 10. Explaining this in angiosperms and gymnosperms is far too difficult; however, it should be explained that this pattern is also followed among higher plants. Concepts 3, 4, 5, 6 and 12.

3. Reproduction in Seed-Bearing Plants

Recall the study of the flower earlier in the year. Students will have forgotten much. Obtain flowers again (gladioli, honeysucke, etc., but no composites) and review the structures. Note that some flowers have both stamens and pistil; some have only stamens (male) and some have only pistils (female). Some plants have only male flowers and some have only female flowers: examples--holly and dogwood.

Explain the function of the anther and the pollen. One student activity was to watch the germination of pollen tubes; so now the students will easily see how the pollen, following pollination, grows down through the tissue of the stigma, style and ovary and through the tiny micropyle into the ovule in which the egg cell is located. The union of the egg and sperm nuclei (fertilization) forms a zygote and the zygote develops into an embyronic plant. Concept 7

4. A Study of Embryo Plants

Open beans and/or corn kernels that have been soaked overnight. The embryo plant and the cotyledons are easily observed. As the bean seeds sprout, the cotyledons can be observed on the stem just above the surface of the soil. The cotyledons will have shriveled up. Ask what happened to them. If some student does not inquire about the pod around the beans or peas, ask about it. Explain that the bean seed developed within the ovary of the flower.

The pod is the ovary wall. The ovary with the enclosed seeds is the fruit. Arrange a display of other kinds of fruit for student examination: apple, tomato, grape, orange and others frequently not thought of as fruits, such as bean pod, corn grain and iris capsule. Have students examine a boll of cotton and determine if this is a fruit. Make sketches of a fruit with enclosed seeds and the embryo plant in the seed. Reference 18, pp. 7-9, reference 3, pp. 280-281 and reference 17, p. 381

Suggested Activities (continued)

5. Reproduction in Pine (gymnosperm)

Observe the "male" (staminate) and "female" (pistillate or megastrobilate) cones of pine. Also observe one-year and two-year cones. Shaking a dry cone will usually cause some of the seeds to fall out. Notice "wings" attached to seeds. Call attention to their function. Concepts 10, 11 and 12. Reference 17, p. 380, reference 5, pp. 167-172

Review alternation of generations and show how gymnosperms and angiosperms fit into the cycle. Call attention to advantages of fruits as compared with naked seeds.

Emerging Concepts

1. All plants come from pre-existing plants.
2. In the plant kingdom, there are many methods of reproduction.
3. In the plant kingdom the following are examples of asexual reproduction: fission in algae; budding in yeast: spore formation in molds, mosses and ferns; production of new plants from parts of old such as is seen in the potato in layering, and buds forming on leaves.
4. The term propagation refers to the production of new plants from parts of old when man aids in the process. Rootings and graftings are examples.
5. Sexual reproduction is seen in the formation of seeds and in alternation of generations in the mosses and ferns.
6. In the plant kingdom, alternation of a sexual generation with an asexual generation is the general pattern for reproduction.
7. Sexual reproduction in flowering plants results in the formation of seeds within the ovary and the flower.
8. The ovary wall plus the seeds forms a fruit.
9. There is great variation in the kinds of fruits.
10. Most gymnosperms produce uncovered seeds in cones (except junipers, and ginkgos).
11. Cones are either staminate or pistillate.
12. There is great diversity in the reproductive processes of plants. As complexity in structure increases, the reproductive process becomes more complex.

Equipment

Algae, fungi, molds (with spores) mushrooms, mosses (with sporophytes), ferns, bean and corn seeds, potatoes (with eyes), African violets, Bryophyllum with buds, Coleus plants, yeast, pictures of specimens not available, flowering plant, Knopf's solution, 250 ml. beaker, 10% sugar solution, pollen grains, empty flower pot and pine cones.

Equipment (continued)

Knopf's solution:

KNO_3 (potassium nitrate) 1 gr., $MgSO_4$ (magnesium sulfate) 1 gr., K_2HPO_4 (potassium dibasic phosphate) 1 gr., $Ca(NO_3)_2$ (calcium nitrate) 3 gr., Water 1 liter

Films

1. Flowers at Work, j-s, 11 min., 284
2. Flowers, Structure and Function, 11 min., Coronet Instructional Films, New York
3. Genetics, Mendel's Laws, 14 min., Coronet Instructional Films, New York
4. Life of Molds, s, 21 min. , 4760
5. Meiosis: Sex Cell Formation, s, 16 min., 5408
6. Mitosis, j-s, 24 min., 5359
7. Plants That Grow from Leaves, Stems, and Roots, e-j, 11 min., 1771
8. Reproduction in Plants, j-s, 14 min., 4177
9. Seed Germination, j-s, 15 min., 5364
10. Thallophytes, Small Bryophytes and Pteridophytes, Stanley Bowmar Co., Inc., New York

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SIMILARITIES AND DIFFERENCES

Introductory Material

In the preceding sections, the students have learned that living things come from other living things. Similarities within groups and differences within and among the groups were stressed. The question now is this: How are these similarities maintained from generation to generation, and what causes the differences? An examination of many of the state-adopted texts reveals an excellent coverage of genetics. The teacher will be referred to the texts for the bulk of the material. The foundation for this study was laid in the foregoing treatment of mitosis and meiosis. If the significance of these two processes was made clear, the laws of inheritance will be more easily understood.

Suggested Activities

1. Crossing Fruit Flies

A long term activity that should maintain interest throughout the study of genetics is the culture of fruit flies through the F_2 generation. This can be done as a class project, with the data from all classes pooled for the final outcome. Obtain pure cultures of wild flies (normal wings, WW genotype), and vestigial winged (ww genotype) flies. These are suggested to avoid the complications of sex linkage with the red eyes. Detailed instructions for culturing the flies come with the specimens. References 20, p. 414; 12, activity 19;22

Have students help make the medium. Under the teacher's directions, virgin females can be put in jars with the appropriate males. Place in a refrigerator several jars for the later F_1 cross. The jars can be observed at intervals. After a week remove the adults from the jar. In about 11 days the flies should emerge from the pupal cases. Have some dependable students assigned the task of anesthetizing and observing the flies. They must keep accurate data. When the F_1 generation has emerged, make crosses of males and virgin females of this generation (F_1). Again the jars must be watched. When the F_2 generation emerges, accurate records must be made of the number of vestigial winged and normal winged males and females. The ratio should come out 3/4 normal winged to 1/4 vestigial winged.

Suggested Activities (continued)

It is assumed that during the three weeks required for the emergence of the F_2 generation, the students will be engaged in various experiences to learn as much as the teacher feels desirable about genetics. As a climax to the study, the results of the fly crossing can be discussed and illustrated and compared to the results Mendel got with his peas and what the books say about other simple monohybrid crosses.

2. Maintaining Similarities and Producing Differences

Have pupils respond to this question: Why are the two paramecia alike which are produced when the parent paramecium divides? If someone comes up with the term mitosis, have the term explained. If not, use leading questions to develop the idea and to show the significance of mitosis. Refer to the exercise in which pipe cleaners were used to illustrate chromosomes. Recall that this type of reproduction is considered asexual, i. e. chromosomes are from one source, one parent. Concept (1)

Ask such questions as: When your cat had kittens or when your dog had puppies, did they all look alike: Did they resemble their parents as much as the paramecia did? How do you explain the difference? By adroit questions bring out the idea that in the case of kittens and puppies the parents were different and the offspring received genes and chromosomes from both parents. Some of the chromosomes of one parent carried genes that were different from those on the chromosomes of the other parent. Films 1, 2 and 3. Concepts 2, 3 and 4

3. Patterns of Inheritance

Illustrate Mendel's work, using colored cutouts of flowers. Pattern or dependable regularity is a key idea here. Gregor Mendel discovered a pattern of regularities in inheritance that are repeated generation after generation.

Use a flat of green and albino corn or sorghum seedlings to further illustrate Mendelian ratios. With this introduction develop further simple Mendelian genetics.

4. The Origin of Abrupt or Unexpected Differences

In Unit II, Unity In Diversity Among Plants, reference was made to the fact that "the way in which inherited changes occur" would come later. During the intervening study the terms gene, chromosome, and DNA have been used and given meaning. After this background the student should be ready to relate mutations to the creation of new, inheritable types.

Consult references to compile a list of kinds of mutations. The following should be considered:

Mutations involving genes (sequence of nucleotide bases may or may not be emphasized)
Changes in chromosome structure
Changes in chromosome number
Mutations that occur naturally and by chance
Mutations that are brought about by environmental conditions
Mutations that may be harmful
Mutations that may be beneficial or useful

Suggested Activities (continued)

Capable students may study and report on the effects of radiations on chromosomes. Obtain irradiated seeds from Oak Ridge or other sources and observe seedlings for mutations.

Have capable students grow onion root tips in colchicine or other similar drugs and observe polyploid cells formed as a result of this drug. Reference 12, pp. 472-473

Have students describe how chromosome doubling in cells is produced by the effects of colchicine.

Have capable students read and report upon practical applications of chromosome doubling by use of colchicine.

5. Analyzing and Substantiating Mendel's Laws

When the F_2 generation of flies has emerged, the study can be climaxed with a review, discussion, exhibition, etc., of the experiment with the fruit flies. The teacher should state all of the terms and concepts considered above with the actual experiment.

For example:

The pure fruit flies were the homozygous parents or F_1 generation.

The trait or gene studied was that for condition of the wings.

The gene for vestigial wings is the allele for the gene for normal wings.

The flies that hatched first were hybrids (heterozygous), members of the F_1 generation. The trait for normal wings was dominant.

6. Man's Development of New Types of Plants and Animals Under Cultivation and Domestication

As special reports or regular class activity, discuss the improvement of plants and animals by farmers over the centuries.

References: 23, 24 and 25

Emerging Concepts

1. As a result of mitosis, the individual cell or organism receives identical chromosomes. The mother and daughter cells are similar.
2. In sexually reproducing organisms, both parents contribute chromosomes to the offspring.
3. The offspring may resemble the mother in some ways and the father in others.
4. The pattern of chromosome behavior in meiosis and fertilization is the basis for the inheritance of characteristics in sexually reproducing organisms.

Emerging Concepts (continued)

5. Gregor Mendel discovered the pattern of inheritance with his experiments with the garden peas. He recognized dominant and recessive traits.

6. Genes on homologous chromosomes exist in pairs. One gene is considered the allele of the other. If both alleles are expressed alike, the organism is homozygous, or pure for the trait. If the alleles are expressed differently, the organism is heterozygous.

7. The term hybrid refers to a heterozygous organism produced by parents homozygous for contrasting traits.

8. P_1 (parental) generation refers to the homozygous parents.

   F_1 (first filial) generation refers to the hybrid offspring of the P_1 generation. All offspring appear alike. F_2 (second filial) generation refers to the offspring of the F_1 generation. The offspring differ in appearance, three resembling the grandparent homozygous for the dominant allele to one resembling the grandparent homozygous for the recessive trait.

9. The term genotype refers to the gene make up of an organism.

10. The term phenotype refers to the appearance of an organism.

11. Genes that are located on the X (or sex chromosome) are said to be sex-linked. Their inheritance conforms to a pattern different from that on the other chromosomes. The alleles for color blindness in the human and red-eye in fruit flies are sex-linked traits.

12. Sex is determined by the inheritance of specific chromosomes designated as X and Y in the human.

13. Changes can occur in genes and chromosomes. They are referred to as mutations and are inherited.

14. Man through his knowledge of the laws of inheritance has developed improved plant and animal types.

Equipment

Onions or onion seeds, beakers or petri dishes, toothpicks or filter paper, colchicine solution, aceto-carmine stain, glass slides and cover slips.

Films

1. The Thread of Life, Bell Telephone Company

2. DNA: Molecule of Heredity, s, 16 min., 5368

3. Genetic Investigations, (12 min.) University of Indiana Audio-visual Center, Bloomington, Indiana

Films (continued)

4. Genetics: Mendel's Laws (14 min.) Coronet Instructional Films, Chicago, Ill.
5. Genetics of Mendelian Populations, (30 min.) in Genetics Series, McGraw-Hill Publishing Company, Text Film Dept., New York, N. Y.
6. Laws of Heredity, s, 15 min., 5409
7. Radiation in Biology, j-s, 14 min., 4301
8. Reproduction in Plants, j-s, 14 min., 4177
9. Reproduction in Animals, e-j, 11 min., 1846

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UNIT V. BIOLOGICAL RESPONSIBILITIES

RESPONSIBILITIES TO ONESELF

Introductory Material

Traditionally, a study of diet includes learning what a balanced diet consists of, such as a yellow vegetable, a potato, meat, etc., as well as the number of calories needed daily. This information is necessary and is provided in most textbooks. The approach to this study is somewhat different in that the students are made aware of why a balanced diet is important to them by relating diet, rest and cleanliness to specific functions that have been taught in the study of the human body at work. The importance of good grooming will be considered.

About 10 days or perhaps a longer period before the unit begins, choose about three responsible students. Have them meet after school and assign them the following task. Secure a tape and tape-recorder and instruct them in the skill of recording. Have them make appointments and visit, after school hours, a heart specialist, doctor (general practitioner), dermatologist, public health nurse, oculist, dentist, orthopedist, a buyer for teen-agers of a local store, etc. Ask these specialists to express themselves on topics discussed in this unit related to their respective fields, and record their statements on tape. Topics that may be suggested to the students are: (1) diet as related to specific body functioning, (2) eating breakfast, (3) candy and cokes, (4) care of teeth, ears and eyes, (5) cleanliness, (6) posture as related to function, (7) good grooming and (8) rest. The tape will be played back during the class period at the appropriate time. The time needed to accomplish this survey will depend upon the local situation. Many of the specialists mentioned will not be available in small communities. In cities, perhaps two or three weeks will be required. The tapes, once prepared, may be kept from year to year.

Suggested Activities

1. Have the students record in their data books a list of all foods that they have eaten for a 24-hour period. Include meals, and snacks such as candy, cokes, bubble gum, etc. Concept 2

2. Understanding the meaning of the term "calorie:" Fill a 1,000 milliliter flask or beaker with water and suspend a Centigrade thermometer in the water. Read the temperature of the water and record. Heat the flask or beaker of water until the temperature of the water is raised one degree. Record this temperature. Allow students to see if they can detect this difference in temperature with their sense of touch. It is estimated that the average boy or girl, age 12 to 13, requires a minimum of about 1 calorie per hour per pound of weight. Have the students calculate the total number of calories they need per day (24 hrs.). From the intake of food for 24 hours previously recorded in data books, have students refer to calorie tables of foods and figure the total number of calories in the food intake per day. Compare total food intake with estimated requirement. Concept 1

Suggested Activities (continued)

3. Foods Contain Energy

   Roll a block of sugar in cigarette ashes and ignite with a match. Ignite a peanut. A piece of string placed in a teaspoonful of melted butter will act as a wick and allow the butter to burn. In what form is energy stored in food as a result of photosynthesis? (chemical bond energy) What is burning? (oxidation) What kind of oxidation? (rapid oxidation) What kind of oxidation occurs in the cells of your body? (slow oxidation) When oxidation occurs in the cells, what two products are formed? (carbon dioxide and water) What has happened to the chemical bond energy when both rapid and slow oxidation occurs? (The chemical bonds are broken down and released as energy in the form of ATP in the body (slow oxidation), and in the form of heat energy as has occurred in burning. Concept 2

4. Ask pupils to bring in extracted teeth of a little brother or sister, or the local dentist will be happy to contribute them. Place one tooth in a stoppered bottle of water and one tooth in several kinds of soft drinks in stoppered bottles. Examine in a week or two. (Some will completely dissolve; others will not be affected). This observation may be extended by using a series of bottles of soft drinks in which a rusty nail replaces the tooth. Concept 2

5. Secure from a local store remnants of different colors of cloth. Ask several students to face the class and drape one by one the different colors of material around their shoulders. Ask the class to select the colors that go best with the coloring of the student's skin, hair and eyes.

6. Have each student draw two simple outline figures exactly alike in his data book as follows. Draw a rectangle one inch by two inches for the body. Draw around a penny to represent the head. Connect these to form the neck. Draw arms and legs exactly the same length and thickness.

   Draw heavy horizontal lines as the costume of the first figure and draw heavy vertical lines as the costume of the second figure. Note that the vertical lines give the appearance of greater height and slenderness than the horizontal lines. Relate this to the selection of clothes for different body builds. Concept 5

7. Getting back to the activities that will lead into the learnings that should evolve. Ask several students to read from their data book the list of foods that they ate during the 24-hour period. Have enough read to point out the crucial points to be investigated, such as diet as related to specific body functioning. At this point, the comments of the specialists on this topic should be played and continued until the material in this section included on the tape is covered. Do not use all the tape at one time, but rather topic by topic, weaving information gained from observations and reading. Concepts 2, 3, 4, and 5

Emerging Concepts

1. The energy of food is measured in Calories. This is a heat unit and is the amount of energy necessary to raise the temperature of 1,000 ml. of water 1° C.

2. Diet as related to specific body functioning:

   Glucose, the end product in the digestion of carbohydrates, is one of the molecules commonly oxidized in the cell that yields energy in the form of ATP. The B-complex vitamins play an important role during these oxidative processes in that they act as carrier molecules. Carrier molecules combine loosely with certain chemical substances and bring them in contact with other chemical substances with which they combine. ATP is the source of energy for all activities of the human organism. Therefore, it would follow that very active boys and girls need a high percentage of carbohydrates and the B-vitamins in adequate amounts in their diet. As activities decrease the proportion of carbohydrates in the diet should decrease.

   Since the ratio of the amounts of hydrogen and oxygen in fats is so much greater than in carbohydrates, about twice as many calories pound for pound are liberated from fats than from carbohydrates. Because of their high calorie concentration, only a small percentage of fats are included in a balanced diet. Fats liberate heat energy to maintain the normal body temperature, about 98.6° F. This temperature is necessary to activate chemical reactions and to help provide the proper environment for the action of specific enzymes. Eskimos require more fat in their diet to maintain their normal body temperature. Some fatty tissue is found throughout the body, so fats furnish materials for the building and repairing of this fatty tissue. The end products of fat digestion, fatty acids and glycerol, can be converted into intermediate substances and thence into the energy molecule, ATP. Excess fat in the diet not only increases the amount of fatty tissue, but it is believed that it will also cause deposits of cholesterol, a fat-like compound, along the arteries, which interferes with the flow of blood to the cells.

   All of the living materials of which cells and hence all tissues are made are primarily protein-like compounds. On digestion, proteins are broken down into 22 or 23 amino acids which are carried by the blood into the cytoplasm of cells. Here the amino acids are combined with minerals into actual tissues such as muscle tissue, blood tissue, bone tissue, brain tissue, etc. Different combinations of amino acids with the addition of certain minerals build specific tissues under the coded directions of DNA in the genes of the chromosomes in the nucleus of cells. All of these building processes require specific enzymes to speed up the reactions and ATP for energy. For example, blood tissue is built from certain amino acids, iron, and calcium; bone and teeth tissue from other amino acids, phosphorus, and calcium; and thyroxin, a hormone produced by the thyroid gland, from another group of amino acids and iodine. Enzymes are built of amino acids. Amino acids and phosphorus are two of the constituents of ATP and DNA.

   Amino acids can be converted into intermediate substances and used as an energy source. However, this involves the use of additional ATP to activate these reactions. This is the basis of a protein-reducing diet.

Emerging Concepts (continued)

Excess weight is an important health problem. Carbohydrates, fats and proteins contain calories and the vast majority of cases of obesity are due to the intake of too many calories. Excess weight produces a strain on the heart; excess fats tend to cause cholesterol deposits in the arteries; excess sugar tends to aggravate an existing diabetic condition; excess proteins may lead to kidney disorders, and excesses of sugar and fats are closely allied with adolescent pimples. Excess weight also has its social implications such as personal embarrassments and shyness in participating in sports and at dances.

A proper eating schedule contributes to efficient body functioning. Research has shown that students who come to school without breakfast are restricted in comprehension or mental alertness. Government programs such as Head Start capitalize on this research and provide breakfast for underprivileged children.

In-between meal snacks, which usually consist of hot-dogs, hamburgers, cokes, candy, potato chips, etc., destroy the appetite at meal-time and do not provide sufficient quantities of each of the nutrients, particularly vitamins and minerals. In addition to the B-vitamins which function in oxidative processes as described above, other vitamins are essential for the prevention of scurvy and rickets, and in the promotion of developmental and functioning processes of healthy tissue and organs. Too many cokes and other soft drinks may upset the acid-base relationship of the body and produce undesirable effects on the teeth.

3. Rest

The systems of the human body are never completely at rest. During sleep, life processes are slowed down, affording the needed rest. Students at Junior High age tire easily; it is an important growth and developmental period of life in which all parts of the body are growing proportionately faster than the heart. The ears need rest from the noises to which teenagers are subjected. Research has shown that hearing of teenagers is becoming impaired because of the long periods of loud music to which they subject themselves. Eyes need rest from television and long reading periods. A minimum of eight hours is needed per day for an average teenager in order for him to develop his fullest potential.

4. Cleanliness

Clean skin promotes a properly functioning and healthy skin. Antiseptic soaps and deodorants are often necessary to prevent bacterial growth and to remove excretory products effectively. Bacterial growth on teeth leads to tooth decay which may be prevented by proper dental hygiene.

5. Grooming

Good grooming includes well styled, clean hair, clean nails, clean appropriate shoes, and clothing in which the color and design flatters the body build.

Equipment

Tape, tape-recorder, 1,000 ml. flask or beaker, Centigrade thermometer, lumps of sugar, cigarette ashes, peanuts, string, melted butter, extracted teeth, stoppered bottle, soft drinks, rusty nails, cloth of different colors and penny

Other Aids

Pamphlets from the State Department of Health, Atlanta, Georgia

Films

1. *Your Food*, e-j, 7 min., 346
2. *Balance Your Diet for Health and Appearance*, j-s, 11 min., 1786
3. *Body Care and Grooming*, e-j-s, 20 min., 4066
4. *Nutrition Needs of Our Bodies*, e-j, 11 min., 1746
5. *Fundamentals of Diet*, j-s, 11 min., 127
6. *The Eyes and Their Care*, j-s, 11 min., 269
7. *The Human Body: Nutrition and Metabolism*, j-s, 14 min., 4317
8. *Vitamins and Your Health*, 17 min., National Vitamin Foundation, Inc. 250 W. 57th Street, New York 21, N. Y.

References

1. *Attractive Teeth for Teenagers and Dental Caries: Prevention and Control*, American Dental Association, 22 E. Superior St., Chicago, Ill., (free).
2. Asimov, I., *The Chemistry of Life*.
3. Beauchamp, W., et al, *Science Is Explaining*.
4. Borek, E., *Atoms Within Us*.
5. Fernald, M. and A. Kinsey, *Edible Wild Plants of Eastern North America*.
6. Fitzpatrick, F., et al, *Living Things*.
7. Fitzpatrick, F. and J. Hole, *Modern Life Science*.
8. Fleck, H. and E. Munves, *Introduction to Nutrition*.

References (continued)

9. Food, Yearbook of the U. S. Department of Agriculture.

10. Gerard, Ralph, ed., Food for Life, University of Chicago Press, Chicago, Free paperback available from the Continental Baking Co., Halstead Ave., Rye, New York, 10580.

11. Health and Safety Pamphlets from U. S. Department of Public Health.

12. Health and Safety Pamphlets from the Metropolitan Life Insurance Company, 1 Madison Ave., New York.

13. Hume, R., Milestones of Medicine.

14. Food Value Charts, National Livestock and Meat Board, 36 S. Wabash, Chicago, Ill.

15. Mason, J. and R. Peters, Life Science - A Modern Course.

16. McCarthy, R., Facts About Alcohol.

17. Mickelsen, O., Nutrition Science and You.

18. Morholt, E., et al, A Sourcebook for the Biological Sciences.

19. Nasset, E., Your Diet, Digestion and Health.

20. Safety Handbook, Science Reserach Associates.

21. Tokay A., The Human Body and How It Works.

22. U. S. Government Printing Office, Nutrition Charts, (Set of 10 charts in color, 19 X 24 in.), Washington, D. C.

23. Wilkins, E., New You, The Art of Good Grooming.

24. Stare, F., Eating for Good Health.

25. Goodhart, R., Teenager's Guide to Diet and Health.

26. Konstant, G., Guide to Skin Care for the Teenager.

RESPONSIBILITIES TO OTHER PEOPLE

A. Prevention of Diseases

Introductory Materials

The development of an appreciation of the human body increases interest leading to a better and more intellectual care of the body. Through research and the use of the microscope, man has been able to isolate, identify and combat several of his germ enemies. He has been successful in his conquest of polio, smallpox, typhoid, diphtheria and scarlet fever. Malaria and yellow fever have been partially controlled by the elimination of their mosquito carriers. As a result of this research and conquest the average life span for man has increased from approximately 33 years to 69 years.

Suggested Activities

1. Secure a health authority to discuss the role of the individual in the prevention and conquest of diseases. The county health nurse would be an excellent resource person. Topics that should be included in discussions are: (1) Shots for prevention of contagious diseases should be taken. (2) There is value in having a complete physical checkup annually. (3) The individual has a responsibility for being aware of the ways in which diseases may be controlled through preventive medical practices. Concept 2

2. Audiovisual aids would be most helpful in the implementation of this subject matter. For example, use a film that illustrates the conquest and control of the mosquito. Concepts 1, and 2

3. The city manager or a councilman might be asked to lead a discussion on what is being done within the local community to control the spread of diseases. Topics for discussion might be the chemical treatment of the water supply, proper sewage disposal, etc. Concepts 1 and 2

4. A short skit may be presented by students to illustrate how specific scientists have made individual contributions in the conquest of disease. Students may wish to dress in the role of the scientists they are representing while presenting pertinent information related to the particular scientists portrayed. Concept 1

Emerging Concepts

1. Scientific research through time has provided man with a number of cures for specific diseases.

2. In the prevention and control of diseases, each individual has a responsibility to others and to himself.

Films

1. Health in Our Community, e-j, 14 min., 5326

2. Your Health: Disease and Its Control, e-j-s, 9 min., 363

Films (continued)

3. Your Health in the Community, e-j-s, 10 min., 464

4. Antibiotics, j-s, 18 min., 4829

5. Body Defenses Against Disease, e-j-s, 10 min., 232

References

1. Simon, H., Microbes and Men.

2. Levine, I., Conqueror of Smallpox: Dr. Edward Jenner.

3. Vallery-Radot, R., The Life of Pasteur.

4. Schneider, L., Microbes In Your Life.

5. DeKruit, P., Microbe Hunters.

6. Hume, R., Milestone of Medicine.

7. Bottcher, H., Wonder Drugs, A History of Antibiotics.

8. Reinfeld, F., Miracle Drugs and the New Age of Medicine.

B. Alcohol, Tobacco and Drugs

Introductory Material

Teenagers are faced with many problems, but of these the use of alcohol, tobacco and drugs are considered to be among the major ones. In the study of these problem areas, it would be impractical to carry on direct experimentation for the purpose of determining the physiological effects of these substances.

Suggested Activities

1. Class members can be instructed to make a list of the advantages and disadvantages that may be found in the use of tobacco, alcoholic beverages, and other substances such as narcotics, pep pills, or LSD. These topics may be treated as one subject or each as an individual subject. Students should not be permitted at this point to make a decision as to whether or not the advantages outweight the disadvantages.

A scientific point of view regarding the use of these substances and their effects may be established rather than that of propaganda, by having the student investigate research material, consult with local and state law officials, investigate medical reports relevant to the subject. At the conclusion of this investigation an evaluation should be made in order to provide each student with an opportunity to express his views which will now be influenced by his research work. Concept 1

Suggested Activities (continued)

2. Since positive and negative attitudes will surely be present at the beginning of this study, the students might wish to use a simple form of debate, preceded by research, to reach a decision. Concept 1

3. Films 1 and 2. Concept 1

Emerging Concepts

1. Professional research shows that marked effects are produced on the bodies of those individuals using alcohol, tobacco, LSD, pep pills, narcotics and other drugs not recommended by a physician. These effects are undesirable and may sometimes prove to be lethal to an individual.

Films

1. Alcohol and the Human Body, j-s, 18 min., 4618

2. Alcohol Is Dynamite, j-s, 11 min., 1234

3. Science of Alcohol, The, j-s, 10 min., 710

References

1. Cain, A., Young People and Smoking.

2. McCarthy, R., Facts About Alcohol.

C. Safety

Introductory Material

National, state and local laws have been devised to protect you with the thought in mind that an ounce of prevention is worth a pound of cure. Thus, it becomes the responsibility of the individual to become aware of these laws, to inform others about these laws and to accept their regulations.

Suggested Activities

1. Investigate your local situation as to specific laws regulating pedestrians. Concept 1

2. Become aware of your state safety laws through research, etc. As an example, one should know the specific laws regulating firearms, etc. Concept 1

3. Films 1 and 2. Concept 1

Emerging Concepts

1. It is the responsibility of the individual to be aware of the laws which regulate his safety, to inform others about these laws, and to obey their regulations.

Films

1. Health in Our Community, e-j, 14 min., 5326

2. Alcohol Is Dynamite, j-s, 11 min., 1234

References

1. Safety Handbook, Science Research Associates.

2. Potthoff, C., American Red Cross First Aid Textbook for Juniors.

3. Health and Safety pamphlets from Metropolitan Life Insurance Company

4. Health and Safety pamphlets from the U. S. Department of Public Health.

D. Developing to Full Potential

Introductory Material

Emotional problems of teenagers usually fall into one of the following groups: (1) home and family, (2) school, (3) individual feelings, (4) plans for the future, (5) how to get along with others, (6) the opposite sex, (7) health, and (8) religious and ethical questions. Each individual has a responsibility to his society and to himself. This responsibility centers around the development of one's mental ability. An individual's mental ability should be developed to its fullest extent, but while he is doing so an understanding should be gained that individuals have individual limitations. An awareness of one's limitations and an acceptance of doing the best with what he has is an education within itself. Regardless of an individual's limitations, it should be stressed that for him there is a place in society.

Suggested Activities

1. Emotional

   Students may be asked to make a list of their personal problems and without a signature to fold and place their list in a suggestion box. The teacher should carefully review the resulting list of problems and should list these on the board for group study and classification. A typical problem might be, "I choke when taking an exam." This would be an excellent topic for beginning this discussion. In discussing these problems, relate no individual to a specific problem. It should be pointed out that any individual when faced with a problem may take a flight reaction, such as putting off; a fight attitude, such as stubbornness, or compromise. A compromise of the three methods mentioned is the best method for solving emotional problems. Concept 1

2. Intellectual

   A professionally trained person, such as a guidance counselor, may be invited to discuss measuring tools, their interpretation and validity. Concept 2

Emerging Concepts

1. People in the same age group usually have similar personal problems and these personal problems can usually be solved by compromise.

2. It is the responsibility of the individual to realize his limitations and to develop his mental ability to the greatest degree possible.

Films

1. Are You Popular?, j-s, 10 min., 395

RESPONSIBILITIES TO ALL PEOPLE OF THE WORLD

Introductory Material

Conservation is perhaps the most important area to be included in the seventh grade science curriculum. It embraces the fundamental processes and relationships which are the foundations for the continuance of the entire biosphere. "Conservation" in years past carried the connotation almost solely of crop rotation and soil erosion. Today its meaning has deepened and its practice expanded to include air, water, forests and wild life. The federal, as well as state governments, allocate millions of dollars each year to the Soil and Water Conservation Service, the Forest Commission, the Wildlife Commission and the Fish and Game Commission. These agencies have established invaluable practices and measures for the wise use and control of natural resources. The results of their efforts are heartening. It has been said, however, that it would be disastrous for the people of our land not to recognize the need for even greater effort in the future. The logarithmic increase in the population-resources ratio and the rapid decrease in the availability of natural resources make this imperative!

It is felt that now is the time for boys and girls of 11 to 13 years to begin to recognize life, water, land and air as natural resources and their responsibility in the stewardship of them. They should not be burdened by exposure to concepts and information beyond their comprehension, but they should come to an understanding of the fundamental principles of ecology. This understanding should lead them to an appreciation of their world and establish a basis for future deeper concepts.

Most texts at this level devote some chapters to this study. It is well for the teacher to utilize to the best advantage this material. However, there is available to every teacher a wealth of material to make this study an exciting adventure. The government agencies mentioned above have excellent educational programs geared to this age level.

Following is a list of a number of agencies to contact for printed materials, information and help of various kinds. It is advisable to contact the person nearest your locality.

Introductory Material (continued)

1. USDA, Soil Conservation Service State Conservationist, Athens, Georgia

   Area USDA Conservationists offices are in Rome, Gainesville, Carrollton, Decatur, Elberton, Perry, Milledgeville, Statesboro, Albany, Tifton, Soperton, Waycross.

   In every county there is a conservationist, technician and county agent available for assistance. A kit, "Material on Soil and Water Conservation," published by the USDA Soil Conservation Service, contains a number of valuable publications.

2. USDA, Forest Service. State Forester: A. R. Shirley, Macon

   District Foresters of the Georgia Forestry Commission can be contacted by writing to District Forester, Georgia Forestry Commission at the addresses indicated.

Route #2
Statesboro, Georgia 30458

P. O. Box 169
Americus, Georgia 31709

P. O. Box 96
McRae, Georgia 31055

P. O. Box 2136
Rome, Georgia 30162

P. O. Box 416
Gainesville, Georgia 30501

P. O. Box 429
Camilla, Georgia 31730

P. O. Box 333
Newnan, Georgia 30263

P. O. Box 881
Milledgeville, Georgia 31061

P. O. Box 1160
Waycross, Georgia 31501

Route #2, Box 266
Washington, Georgia 30673

3. University of Georgia
   College of Agriculture
   Cooperative Extension Service
   Athens, Georgia 20601

4. American Forest Products Industries, Inc.
   District Manager
   916 Standard Federal Building
   Atlanta, Georgia 30303

5. Game and Fish Commission
   Information Officer
   State Capitol Building
   Atlanta, Georgia 30334

6. Water Quality Board
   State Capitol Building
   Atlanta, Georgia 30334

Suggested Activities

1. Obtain materials from the suggested sources. Study carefully and prepare a unit that will best fit your situation.

2. Contact the county agent, soil conservationist, wildlife expert and forester in your county or area for specific help in working out a meaningful experience. They are available for talks, illustrated lectures and various kinds of help and are familiar with the conservation projects and practices in the local area.

3. Organize students for group work and projects in the various areas of conservation. They can request information and prepare reports for the benefit of the whole class.

4. Lead a discussion on the individual's responsibility in using and caring for the life about which he has been studying all year and the land, water, soil and air around him. Students can prepare exhibits, posters, etc., as illustrations.

5. Field Study of Natural Protection and Food for Wild Animals

   Plan to carry out a field study of natural homes of wildlife in your community, giving particular attention to types of cover or protection and natural sources of food. Notice and record observations of nesting sites, burrows and other places that represent cover where young may be protected. Have the pupils observe and list agricultural and forestry practices that increase cover and food supply and those that have the opposite effect. References 1, 13, and 17

6. Bulletin Board Display

   Have the pupils prepare a bulletin board display, showing types of animals that serve as biological controls for other organisms. Use picture diagrams where possible. Identify controls and pests or predator and prey. References 11, 15, 22, 23, 28, and 31. Film 2

7. Study of a Food Chain

   Choose an available plot of land near the classroom and have pupils observe and attempt to trace any evidence of a food chain (or web) that may exist among the organisms present. Identify producers, first order consumers, and second order consumers. Also look for evidence of decomposers. Have the students report their findings in a paper or by use of a chart and diagrams which show the various relationships.

8. Experiment on the Water-holding Capacity of the Soil

   Select three large funnels of the same size. Fill the first with clay, the second with sand, and the third with dry humus, with equal volumes in each funnel. Set up a support for each funnel, and place a jar or beaker beneath each to catch the water that will pass through. Have one of the students pour equal amounts of water into each of the three funnels. Measure and record the amounts of water that flow through each. Which soil permits the water to flow through most quickly? Which type of soil retains the most water? Discuss with the students the implications of your findings for conservation and plant growth.

Suggested Activities (continued)

9. Special Reports

Have pupils prepare written or oral reports on one of the following topics:
The establishment, maintenance and value of National Forests
Prevention of forest fires in Georgia
The economic importance of forests
The establishment, maintenance and value of State Parks in Georgia
Effect of insecticides on the wild bird population

References 7, 8, 11, 14, and 24. Films 11 and 19

10. The Web of Life in a Pond

Have a group of students (on a week end) collect samples of water and contained organisms from different parts of a pond—shallow water, weeds along the shore, mud at the bottom, floating plankton, etc., and have each container labeled to indicate the source. Bring the samples into the laboratory and have members of the class examine the material under the microscope.

To the extent possible, identify and classify the various organisms as to their ecological roles, i. e. as producers, consumers, of various orders. Attempt to diagram a food chain (web) of the organisms present.

Have pupils attempt to answer the following questions:

Why do farmers and sportsmen fertilize their fish ponds periodically?

Why are several kinds of fish usually used to stock a pond?

What effect would mud and silt washed into a pond have on the fish population?

References 23, 30 and 31. Films 17 and 2

Identification References 6, 7, and 10

11. Individual Projects on Food Chains

Have one or several students choose one animal species that occurs in your community. If several students are involved, each should choose a different species. Have each student work out a food chain for his animal and construct a diagram of the principal food relationships. Have each student compare his diagram of a food chain with those drawn by other students. If possible have them discover those points where the food chains join or overlap. If possible reconstruct a larger food chain (web) based upon the composite findings of several pupils.

References 23, 27, 28, 29 and 31

Suggested Activities (continued)

12. Non-living Factors of the Environment

Have the students gather information about the non-living factors that influence living things in your community. List such factors as soil, light, air pollution, altitude, date of first and last frosts, rainfall, temperature range, etc.

Compare the data gathered with similar data for New York and Kansas. Try to establish a causal relationship between environmental factors and natural vegetation of the three places studied.

References 10, 19 and 30

13. Conservation Field Trip

Have the students plan a field trip in your community to observe conservation practices. If possible, arrange to visit eroded areas, examples of terracing, strip cropping and contour plowing. Also observe dams and drainage ditches. By use of questions bring out the advantages or disadvantages of the observed practices. Observe any other devices, such as use of ground cover shrubs, etc., to prevent or check erosion. Work out your own plans for a report or reports to fit the area studied.

14. Conservation Practices in Urban Areas

Have your students discuss and identify conservation problems facing urban areas. Point out that conservation is not restricted to farming, mining and forestry. Have them find out what they can about city conservation practices. What is the relationship of "urban renewal" to conservation? Base a report on conservation activities in your city on observations, interviews with or talks by city officials, and newspaper accounts.

15. Experiment on Splash Erosion

During heavy rain, as raindrops strike the earth, soil particles are dislodged and splashed distances ranging from several inches to two feet or more. Splash erosion may account for much of the soil erosion commonly observed.

Have the pupils prepare two splash boards 3½ feet long, 1 in. thick, and 4 in. wide. Sharpen one end to be driven into the soil. Paint the boards white and mark them at one-foot intervals, starting 6 in. from the sharpened end. Drive one board into the ground to a depth of 6 inches on a grassy plot and the other on a plot of bare ground. After the first heavy rain, observe both boards and compare. How high have the soil particles been splashed? What can be concluded from the observations?

16. Natural Resources of Daily Use

Call upon the students to list on the chalk board the names of everyday products that are commonly used -- plastics, nylon, synthetic yarns, drugs, steel, aluminum, gas, petroleum products, specific foods, spices, chocolate, flavorings, detergents, cosmetics, paper and the like. Have them arrange a display of samples of materials with bright threads extending from the samples to places on a world map or map of

Suggested Activities (continued)

the United States from which the products or raw materials come. A visit may be arranged to an industrial plant where raw products are converted into manufactured goods. A display of steps in the processing of certain products may be arranged. Discussion should bring out what is meant by "raw materials," and that the sources of raw materials are the air, the sea, the earth and living things. Have the students give examples of products from each of these sources. Students may be encouraged to engage in cooperative library research on this subject and report for the benefit of the class. Have students distinguish between renewable and non-renewable natural resources. Have them discover published estimates of how long several of our non-renewable resources will last at present rates of consumption. Raise the question of the responsibility of this generation of people for the natural resources that will be needed by future generations. Consider various suggestions as to what can be done to conserve natural resources more effectively.

References 16, 25, 15 and 3

17. Pollution Control

Have members of the class investigate the laws which attempt to control pollution in your area. Determine whether these laws, if they exist, are being enforced. Investigate industrial and municipal sewage problems. Arrange a report to the whole class.

Emerging Concepts

1. The continuation of satisfying and productive human life depends on the wise use and renewal of the earth's resources.

2. Conservation means the wise use and minimum waste of natural resources and provision for their renewal when possible.

3. The environment includes all of the things, living and non-living, that surround you and other living things.

4. Plants and animals exist as populations of species which live in natural communities in which various members depend upon each other. Man is part of the living community and shares its interdependence.

5. Natural resources are of two types: renewable (forests, water, wildlife, air, soil) and non-renewable (petroleum, coal, oil, gas, etc.).

6. Materials (matter) of which resources are composed go through cycles involving both the living community and non-living environment (ecosystem, biosphere) from generation to generation and from year to year.

Suggested Activities (continued)

7. Energy enters the biosphere as light energy from the sun and is captured and stored through the process of photosynthesis. Energy passes through the system of living organisms from producers through various consumer levels (energy pyramid).

8. A natural pattern of eating and being eaten maintains a changing balance in populations of living things, a balance in nature (food web). Food chains and food webs bind the various species populations of a community into a complex, interdependent structure.

9. Man is guilty of transgressing natural laws by his unwise misuse of both living and non-living natural resources. He has increased the disruption of the web of life in nature. The damage he has done has increased with the passage of time. Time is now running out and there is not much time left to correct mistakes. If man does not act as though he realizes that he himself is a dependent part of the natural community and begin to manage his resources more wisely, the quality of his life will deteriorate and his survival as a species will be threatened.

10. The resources of the earth are held in trust by each generation for the following ones. Each boy and girl shares in this responsibility.

Films

1. Arctic Wilderness, (set of 6 filmstrips) Encyclopedia Britannica Films, Inc., 1050 Wilmette Ave., Wilmette, Ill.
2. Balance in Nature, (19 min.), Filmscope, Inc., Box 397, Sierra Madre, Calif.
3. Conserving Our Forests Today, e-j, 11 min., 1783
4. Conserving Our Soil Today, e-j, 11 min., 1782
5. The Desert, j-s, 22 min., 5513
6. The Grasslands, j-s, 16 min., 5389
7. The High Arctic Biome, j-s, 22 min., 5360
8. Nature's Half-acre, e-j-s, 33 min., 7052
9. Soil Conservation Series (4 parts, 10 minutes each), U. S. Department of Agriculture, free
10. Succession: From Sand Dune to Forest, j-s, 16 min., 5362
11. The Temperate Deciduous Forest, j-s, 17 min., 5390
12. The Vanishing Prairie, (set of 6 filmstrips) Encyclopedia Britannica Films, Inc.

Films (continued)

13. *The Web of Life Series*, (set of 2 films: *A Strand Breaks*, j-s, 17 min., 4745 and *The Strand Grows*, j-s, 15 min., 4825
14. *Yours Is the Land* (21 min.), Encyclopedia Britannica Films, Inc.
15. *Forest Conservation*, j-s, 11 min., 434
16. *Forests and Conservation*, Coronet Instructional Films., e-j, 10 min., 645
17. *Muddy Waters*, U. S. Soil Conservation Service, Washington, D. C. 20240
18. *The River*, j-s, 30 min., 7459
19. *The Story of the Forest*, American Forests Products Industries, Inc., 1816 N. St., N. W., Washington, D. C. 20036

References

1. Allen, D., *Our Wildlife Legacy*.
2. Bates, M., *The Forest and Sea*.
3. Beauchamp, W., et al, *Science Is Explaining*.
4. Brandwein, P., et al, *Life: Its Forms and Changes*.
5. Bronson, W., *Freedom and Plenty: Ours to Save*.
6. Callison, C., *America's Natural Resources*.
7. Carson, R., *Silent Spring*.
8. Collins, W., *The Perpetual Forest*.
9. Dansmann, R., *The Last Horizon*.
10. Farb, P., et al, *Ecology*.
11. Farb, P., et al, *The Forest*.
12. Fenton, C. and D. Pallas, *Trees and Their World*.
13. Fitzpatrick, F., *Our Animal Resources*.
14. Fitzpatrick, F., *Our Plant Resources*.
15. Fitzpatrick, F. and J. Hole, *Modern Life Science*.

References (continued)

16. Fitzpatrick, F., T. Bain and H. Teter, *Living Things*.
17. Green, I., *Wildlife in Danger*.
18. Grimm, W., *The Book of Trees*.
19. Heffernan, H. and G. Shaftel, *Man Improves His World*.
20. Hegner, D., *Conservation in America*.
21. Hyde, M., *Plants Today and Tomorrow*.
22. Kane, H., *The Tale of a Meadow*.
23. Kendeigh, C., *Animal Ecology*.
24. Lauber, P., *Our Friend the Forest*.
25. Mason, J. and R. Peters, *Life Science*.
26. Matthiessen, P., *Wildlife in America*.
27. Parker, B. and R. Buchsbaum, *Balance in Nature*.
28. Parker, B., *Plant and Animal Partnerships*, *Saving Our Wildlife*.
29. Pettit, T., *The Web of Nature*.
30. Smith, R., *Ecology and Field Biology*.
31. Storer, J, *The Web of Life*.

Identification References

1. Forest, H., *Handbook of Algae*.
2. Hausman, L., *Beginners Guide to Freshwater Life*.
3. Jacques, H., Ed., "How to Know" series.
4. Jahn, T., *How to Know the Protozoa*
5. Morgan, A., *Field Book of Ponds and Streams*
6. Needham, J. and P. Needham, *A Guide to the Study of Fresh-Water Biology*.
7. Pannack, R., *Fresh-Water Invertebrates of the United States*.
8. Prescott, F., *How to Know the Fresh-Water Algae*.
9. Smith, G., *The Fresh-Water Algae of the United States*.
10. Ward, H. and G. Whipple, *Fresh-Water Biology*.

Special Reading Reports

1. Wildlife in a City Environment

   A student who is interested in how wildlife gets along in a city may enjoy reading and reporting on John Kieran's Natural History of New York, Houghton Mifflin Co., Boston, Mass.

2. Reports may be made to the class based upon the following timely references:

   Editors, "The Fouling of the American Environment," Saturday Review, May 22, 1965.

   Conservation Yearbook, Quest for Quality, U. S. Dept. of the Interior, 1965, p. 17.

   Braidwood, Robert J., "The Agricultural Revolution," Scientific American, April, 1958.

   Cole, LaMont C., "The Ecosphere," Scientific American, April, 1958.

   Woodwell, George M., "Toxic Substances and Ecological Cycles," Scientific American, March, 1967.

TEACHER AND STUDENT REFERENCES
Life Science

Allen, Durward, Our Wildlife Legacy, Funk and Wagnalls, New York, 1954.

Allen, Ross and Wilfred Neill, Keep Them Alive, Reptile Institute, Silver Springs, Florida, 1954.

Andrews, Roy C., All About Whales, Random House, New York, 1958.

Asimov, Isaac, Chemicals of Life, New American Library, Doubleday, Garden City, New York, 1962.

Asimov, Isaac, The Genetic Code, Signet, New American Library, New York, 1962.

Asimov, Isaac, The Human Body: Its Structure and Operation, Houghton Mifflin, Boston, 1963.

Asimov, Isaac, The Human Brain: Its Capacities and Functions, Houghton Mifflin, Boston, 1963.

Asimov, Isaac, Life and Energy, New American Library, Doubleday, Garden City, N. Y., 1962.

Asimov, Isaac and W. Boyd, Races and People, Abelard Schuman, New York, 1955.

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MAJOR ITEMS OF EQUIPMENT
Life Science

Item	Approx. No. Needed
Bunsen burners	3
Thermometers, Centigrade	2
Thermometers, Fahrenheit	2
Set of weights, gram	1 set
Balance, platform	1
Microscopes	6
Stereomicroscope	1
Hand lens	25
Bioscope	1
Cover slips	1 oz.
Glass slides	1 gross
Glass slides, depression	1 doz.
Forceps	1 doz.
Nets, insect	3
Terrarium	1
Aquarium	1
Dissecting pans	6
Hot plate	1
Pressure cooker (sterilizer)	1
Bell jars	3
Test tube holders	1 doz.
Test tube racks	2
Funnels	6
Test tubes	72
Flasks	1 doz.
Stoppers, cork	assortment
Stoppers, rubber	3 lbs.
Evaporating dish (90 x 22 mm.)	2
Petri dish	24
Beakers, 250 ml.	12
600 ml.	6
1000 ml.	2
Eye droppers	2 doz.
Ring stand	3
Support rings, 5" dia.	3
Wire gauze, 6"	3
Stethoscope	1
Y-tube, 10 mm.	2
Rubber tubing, ¼"	12
Scissors	12
Teasing needles	1 doz.
Incubator	1
Dishes, specimen (finger bowls, culture dishes)	12

MISCELLANEOUS SUPPLIES
Life Science

These items may be brought to class by students or purchased by the teacher on the local level.

- Cotton cloth
- Food coloring
- Metal
- Onion
- Paper cup
- Plastic cup
- Salt
- Saccharin
- Sandpaper
- Soft toy
- Vinegar
- Ice
- Football
- Ruler
- White Paper
- Glue
- Modeling Clay
- Jars
- Pond water
- Soil sample
- Trowels
- Cardboard boxes
- Black paper
- Celery
- Gladiola blooms
- Growing plants
- Bean seeds
- Elodea
- Razor blades
- Algae
- Corn seeds
- Ferns
- Molds
- Mushrooms
- Pollen grain
- Yeast
- Pan (approx. 14" x 18")
- Cigarette ashes
- Extracted teeth
- Penny
- Soft drinks
- Blank tape (for recording purposes)
- Two pieces of board, 6 in. long
- Two pieces of glass, 14" x 18"
- Balloon
- Unstained blood smear (from hospital)
- Butter
- Cardboard
- Cooking oil
- Cornstarch
- Cow or chicken heart (local abbatoir)
- Egg white
- Karo syrup or molasses
- Kidneys(market)
- Sausage casing (market)
- Spoon
- Stained blood smear (from hospital)
- String
- X-ray transparencies of bones (from local hospital)
- Thread
- Toothpicks
- Construction paper
- Bell
- Wrapping paper
- Pipe cleaners
- Adhesive tape
- Banana
- Cotton swabs
- Frog and toad eggs
- Nails
- African violets
- Coleus plants
- Empty flower pots
- Fungi
- Mosses (with sporophytes)
- Pine cones
- Potatoes (with eyes)
- Fruit flies
- Pipe cleaners
- Cotton cloth of different colors
- Peanuts
- Rusty nails
- Sugar
- Tape recorder
- Two pieces of board, 3/4 x 3/4 in. by 11¼ in. long

LIVING ORGANISMS
Life Science

Item	Approx. No. Needed
Amoeba	Class of 12
Paramecium	Class of 12
Hydra, budding	Class of 12
Euglena	Class of 12
Planaria	Class of 12
Tetrahymena pyriformis	Class of 12

CHEMICALS
Life Science

Item	Approx. No. Needed
Alcohol, ethyl	1 pt.
Ammonia	1 pt.
Formalin	1 gal.
Calcium hydroxide, limewater tablets	per hundred
Iodine solution	1 pt.
Ether	1 lb.
Aluminum foil	1 pkg.
Methylene blue	4 oz. (sol.)
Benedict's solution	8 oz.
Fehling's solution A	4 oz.
Tes-tape	1 roll
Fehling's solution B	4 oz.
Ammonium hydroxide	1 pt.
Nitric acid	1 pt.
Potassium nitrate	4 oz.
Magnesium sulfate	4 oz.
Potassium dibasic phosphate	4 oz.
Calcium nitrate	4 oz.
Pepsin	25 g.